E-ISSN: 2707-8213
P-ISSN: 2707-8205
IJAE 2022; 3(1): 01-11
Received: 09-11-2021
Accepted: 14-12-2021

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Analytical design of go-kart using optimization techniques

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Abstract
The main objective of this paper is to give detailed design calculations and analysis of go-kart vehicle parts. Go kart is a four-wheel racing vehicle & since there is no suspension and no differential when both rear tires turn at the same speed. The intention of this paper is to model and analysis of go-kart vehicle parts according to their design calculation and simulation deals with Finite Element Analysis (FEA). The design of the Go-kart has been prepared in solid-works software. Obtaining the optimization Method used in the study such as MOORA (Multi-Objective Optimization based on Ratio Analysis), Entropy method (For estimating the weights of the individual parameters), and AHP (Analytic Hierarchy Process study for the Optimal material selection of the Go-kart chassis), the selection of the optimal engine for the process, and the optimal design of the Chassis by observing the deformation in the system.

Keywords: Optimization process, design analysis, entropy method, empirical analyses, chassis.

Introduction

A small 4-wheeled car powered by using -a stroke or four-stroke internal combustion engine or electric powered motor with an unmarried seater is called a cross-kart. Go-karting originated in the United States in the 1950s, A Go-kart using definition has no suspension and no differential. The layout process of the car is iterative and is based on various engineering and reverse engineering procedures relying upon availability, cost, and different elements. So, the layout method focuses on the subsequent objectives: Safety, serviceability, energy, ruggedness, standardization, fee, and use. With this, we had a view of our kart and we set up some parameters for our paintings and distributed ourselves in companies for the layout of our car. In the go-kart, the placement of the engine places an important role all the engines are not flat as considered. The engine needs a mount for holding the optimal design and the simulation for that has been discussed in the paper [2]. The majority of Go-Kart uses the Two Stroke or the 4-stroke Engine the possibility of the electric engine or the electric motor which can easily replace the engine has high importance [5, 8, 15]. The Chassis is an important component in the Go-Kart generally the chassis are known to be the backbone of the vehicles the design methodology of the Go-kart has been observed in the simulation performed in this study [7]. In the study of the Go-kart, one task the manufacturing of the Kart is another important task the manufacturing of the task must have so many difficulties for the Manufacture such as Uncertainty in the design and the error in the measurement and the kind problem with solution has study in the ref [10, 11, 13]. There are so many works conducted in the study of the design and analysis of the Go-kart but the major amount of the work is to determine the optimal design of the chassis the review of the design of the chassis has been performed in the study conducted by the [19]. Design and manufacture a safe, functional and economical go-kart from scratch. Efforts have been made to make the frame rigid and torsion-free and to increase the performance of the vehicle. The secondary objective is to optimize the vehicle to the best of our abilities [22]. AHP manner is a Multi-Criteria Decision Analysis (MCDA) or frequently referred to as Multi-Criteria Decision Making (MCDM), (Linkov *et al.*, 2004) [25] is a way that includes a regulated set of methods that helps selection makers to decide or to make a crucial decision on the premise of numerous standards orbiting that choice. The MCDA methods are very well accepted when verdict makers have to take a choice on numerous and disagreeing reviews.

Analytic Hierarchy Process (AHP) is the maximum recommended and maximum suitable MCDM approach that became developed using T. Saaty (1977, 1980, 1988, and 1995) [23, 22]. The Entropy method is used to determine the Weight of factors when the data of the decision matrix is known it was proposed by C.E. SHAMNON in 1948. It was an Objective type of weighting method. The Entropy method consists of 4 steps as follows [21]. The MOORA is a method used to obtain the optimal result by separating the Desirable and undesirable values The Steps involved in this Method are as follows [24].

Design & Methodology

The design of the Go-kart is presented upon.

Basic assumption for the design of chassis of the go-kart

We approached our layout by thinking about all viable alternatives. The design procedure of the car is iterative and is based totally on various engineering and reverse engineering strategies depending upon the provision, value, and different such elements. So, the layout technique specializes in the following goals. Body individuals round move-sections. Safety & Strength, Standardization & Serviceability, Cost, Ergonomics and egress time, Driver safety, and Basic Dimension for the Design.

Table 1: Table caption

Parameters	Values (in mm)
Front track width	1050
Rear track width	1075
Wheelbase	1180
Overall length	1700
Overall height	980
Overall width	1075

Table 1 represents the basic design for the Go-kart. For the Chassis, we considered three materials as shown in Table 2 below and for the Chassis design, we considered them as shown in Table-3. The materials are selected for the references [4, 6, 9].

Table 2: Property of the material for the Fabrication of the chassis

Material name	Ultimate tensile strength	Young's Modulus	Machinability	Availability	Density
AISI 1018	440	200	0.68	3	7870
AISI 4130	560	210	0.70	4	7850
AISI 1020	420	205	0.71	2	7870

Table 3: Cross section of the pipe selected for the chassis design

Model	Dimension of the Chassis Pipe
M1	25.4mm*2.0mm
M2	26.9mm*3.2mm
M3	21.3mm*2.3mm

The Above table 2. Representing the material, we selected the AISI different Grades since these are optimal materials used in the fabrication of the Go-kart the AISI 1080, 4130, and 1020 are the most important material among all the materials. Table 3 represents the pipe cross-section selected in the design based on the ISO standards with the circular cross-section the initial value represents the inner Diameter of the pipe and the next value represents the thickness of the rod.

The Consideration for the Driver Ergonomic

Driver ergonomics focuses on the health aspects of the driver, drawing upon biological & engineering design to create a vehicle environment in which drivers have a lower chance of injury. The optimal values are considered from the [1, 16] the cad model is produced for the simulation and observation.

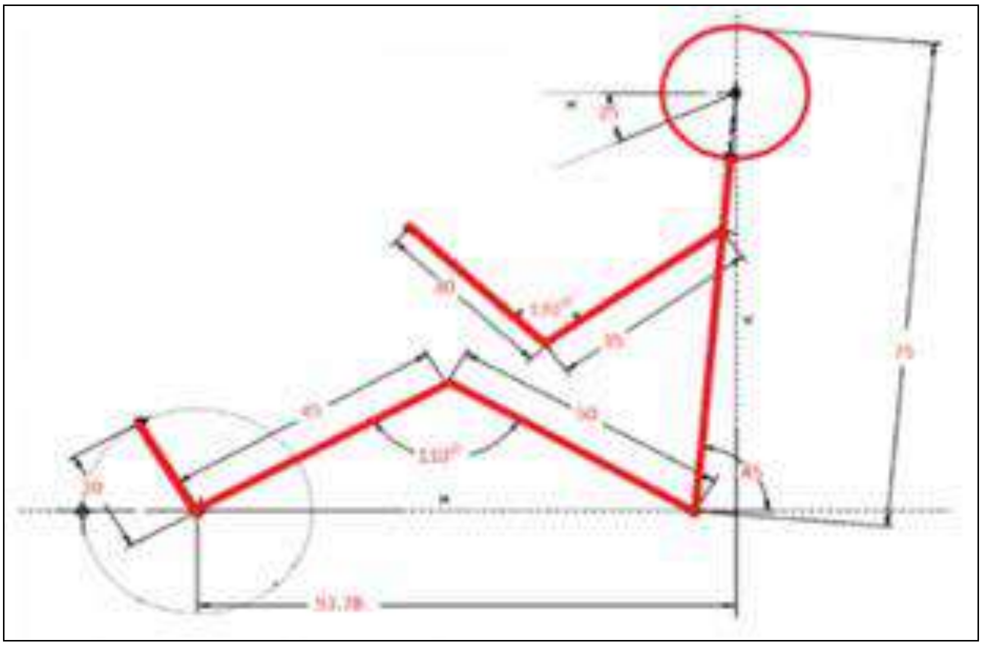

Fig 1: Ergonomic Design of the driver in 2d Considered form the reference

Fig 2: Ergonomic Design of the driver in 3d. Designed in the 3D-Experiences Software.

The design of the Go-Kart Driver Ergonomic has been performed in the 3D-Experience Software the Dassault system software used for the design and analysis and manufacturing process.

Preliminary Design Calculation

The design calculation for the design of the Go-Kart we be required to Calculate the Design parameters the follow calculation required the design of the chassis.

- Steering System Calculation.
- Breaking Calculation.
- Engine and Transmission Calculation.

Steering System Calculation

The Steering calculation is required to design the overall Go-Kart the design is as follows:

The turning radius of the vehicle is designed for a turning radius of 2 m. The track width and wheelbase are decided as 40 inches and 41.33 inches respectively. For steering of Go-Kart, we considered the Ackermann steering Gare mechanics [18].

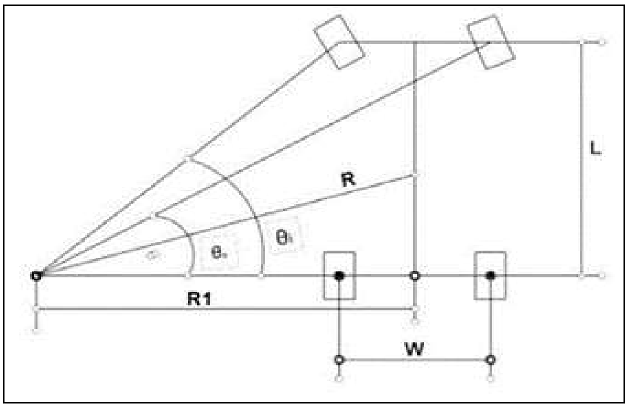

Fig 3: Ackermann steering design

Wheel base = 1190 mm

Track width = 1000 mm

R = 2000mm

Length of steering arm = 120 mm0

$ø = \tan^{-1} \{1190/ [2000 – (1000/2)]\}$

$= 38.426`$

$Ɵ = \tan^{-1} \{1190/ [2000 + (1000/2)]\}$

$= 25.45`$

$B = \tan^{-1} \{1190/ [(1190 / \tan (25.45))-1000]\}$

$= 38.41`$

Length of stud axle C = 1000 – (2*105)

= 790mm

$R_{in} = [1190/\sin (38.426)]$

$= 1914mm$

$R_{out} = [1190/\sin (25.45)]$

$= 2769mm$

Steering Condition

$\cot (25.45) – \cot (38.426) = 1000/1190$

$(2.101 – 1.2065) = 0.84$

$0.84 = 0.84$

$\sin\beta = Y/120$

$\sin (38.41) * 120 = Y$

$Y = 74.55$

$2L = C - 2Y$

$= (C – 2Y) / 2$

$= \{[790 – 2(74.55)]/2\}$

$= 320.45mm$

Table 4: Cross section of the pipe selected for the chassis design

Steering Parameters	Values
Steering type	Ackerman
Steering column	Rigidly mounted
Steering wheel diameter	270 mm
Steering effort	4.5N-m
Turning radius	2m
Average steering angle(degrees)	42^0
Maximum turning angle(degrees)	45^0
Ackermann percentage (%)	100.04%
Ackermann angle(degrees)	38.41^0
Steering ratio	1:1
Length of tie rod	320.45 mm

Breaking Calculation

For the breaking we had considered that the caliper and master cylinder for the existing model [12].

Calliper

- Double piston calliper
- Brand-Endurance /KBX/ Bybre
- Double piston calliper
- Weight-950 grams
- Single outlet master cylinder with reservoir

Master cylinder

- Single outlet master cylinder
- Brand-Endurance with KTM reservoir
- Weight: 350 grams

The Calculation of the brake pressure or break force

- **Gross Weight of the vehicle:**

W = weight of the vehicle (with load) in kgs * 9.81

= 170 * 9.81 = 1667.7N

- **Brake line pressure**

p = force on the brakes/area of master cylinders (as the pedal ratio is 2:1)

(Assume the normal force applied on the pedal: 200N)

= pedal ratio * (force on the pedal / area of master cylinder)

= $2*(200/(\pi/4) * (0.01)^2)$

= 5.09 Mpa

- **Clamping force**

CF = brake line pressure* (area of calliper piston*2)

= $(5.09*10^6) * ((\pi/4) * (2.54*10^{-2})^2 * 2)$

= 5158.2821N

- **Braking force**

BF = CF* No of Brakepads * coefficient friction of brake pads

= 5158.2821*2*0.3

=3094.9693N

Braking torque (t_n) = Braking force* effective disc radius

Effective Radius, R= 0.085m (Constant pressure)

Effective Radius, R= 0.08588m (Constant Wear)

We have considered least effective radius

BT = 3094.9693*0.085= 263.072N-m

(Torque available at the two lines of the rear shaft)

- **Rotating force = (braking torque / tire radius) * 0.6(Coefficient of friction)**

(Tire Diameter is 11in = 0.1397m)

= (263.072/0.1397) * 0.6

= 1129.8742N

- **Deceleralation**

f = -ma (-ve sign indicates force in opposite direction)

a = -RF/m = -1129.7425/170

= $-6.6463 m/s^2$

- **Stopping distance**

$v^2 - u^2 = 2*a*d_s$ (v=0 m/s)

At u = 9.2872 m/s = 33.12 kmph

Stopping Distance = 6.488 meters

At u = 8.333 m/s = 30 kmph

Stopping Distance = 5.223 meters

Engine and Transmission Calculation

For the Go-Kart we had following Engine with following

Table 5: Engine Specification

Model	Bajaj discover 125ST
Engine type	Vertical Single Cylinder Four Stroke
Bore ×stroke	54*49mm
Displacement	$124.66 cm^3$
Cylinders(qty)	1
Cylinder Bore	Cast Iron
Net torque	11Nm @ 7000rpm
Type of fuel	Gasoline

Engine Dimensions

- Length - 29cm
- Width - 29cm
- Height - 44cm

The assumptions made for the Transmission are as follow

Sprocket ratio = 2:1

Efficiency: 80%

Gradeability is 25deg

Chain sprocket

Power is conveyed by a roller chain known as a drive chain or transmission chain passing over a sprocket gear meshing with the hole in the links of the chain

The drive gear consists of 14 teeth and the driven gear consists of 28 teeth

- The Transmission calculation of gear:

The Torque at wheel, velocity, and the acceleration at different gear

At Gear 1

- The Torque at the pinion (T_p) = Torque at engine * First gear ratio * eff * primary
  =11 * 2.83 * 3.08 * 0.8
  = 76.70432
- Torque at Sprocket (Ts)
  = Torque at pinion * sprocket ratio
  = 76.7043 * 2
- Speed at pinion (Np) = Engine speed / 3.08*2.83
  = 7000/3.08/2.83
  = 803.083 RPM
- Speed of Sprocket (Ns) = 803.083/2
  = 401.5419 RPM
- Power (P) = 2NπT/60
  = 2*3.14*401.5419*153.408 / 60
  = 6447.46 KW
- Time(T) = $Mv^2/2*P$ = 0.4544 s
  Velocity(V) = r * ω
  = (0.1397 * 2 *3.14 * 401.541)/60
  = 5.8713 m/s
- Acceleration(a) = v/t = 5.8113/0.4544 m/s^2

Similarly for the other values achieved in at the gear are as follow.

Table 6: Values of torque produced and velocity produced by the engine at different gear

Gear Reduction	Gear Ratio	Torque at Wheels (Nm)	Velocity (m/s)	Acceleration (m/s^2)
1st GEAR	2.83	153.40	5.871	12.092
2nd GEAR	1.79	97.0322	4.2872	8.1724
3rd GEAR	1.33	72.09664	12.4994	6.0717
4th GEAR	1.08	58.5446	15.3925	4.9303
5th GEAR	0.91	49.3292	18.2684	4.3981

Selection of the material for the Go-kart chassis using AHP

The phase of the material is done on the idea of the AHP method. The popular cloth was taken into consideration from the AISI 1018, AISI 4130, and AISI 1020. The AHP process is a Multi-Criteria Decision Analysis (MCDA) or regularly referred to as Multi-Criteria Decision Making (MCDM), (Linkov *et al*., 2004) [25] is a technique that contains a regulated set of techniques that allows choice makers to determine or to make important decisions on the premise of numerous standards orbiting that choice. The MCDA methods are very well acceptable whilst verdict makers should take choices on several and disagreeing critiques. Analytic Hierarchy Process (AHP) is the most endorsed and most ideal MCDM approach that became evolved by using T Saaty (1977, 1980, 1988, and 1995) [22, 23].

The primary principle involved in AHP is as follows:

- The decomposition principle of AHP requires the choice problem to be decomposed into a hierarchy that captures the critical factors of the choice trouble. Decision elements are in addition decomposed into sub-elements.
- Construction of pair-smart comparison matrices at each decision stage. Aggregating the various factors to calculate the relative importance of the factors and the sub-factors.

Table 7: Values of torque produced and velocity produced by the engine at different gear

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to objective
3	Moderate importance	Experienced and judgment slightly favour one activity over another
5	Strong importance	Experienced and judge strongly favour one activity over another
7	Very strong or demonstrated importance	An activity favoured very strongly over another; it is dominance denominated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between the Two adjacent Judgement	When Compressions needed
Reciprocals of above	If activity i has one of the above non zero members assigned to it when compared with activity, j, then j has the reciprocal value when compared with I	A reasonable assumption

The consistency check involves two further steps. They are:
Analytical Hierarchy Process

- Generation of a matrix of Consistency Values (CVi, j)
- Arriving at an array of Consistency Weights (CWi,)
- Calculation of an array of Weighted Sum of Criteria Values (WSVi) which is the sum of the products of Criteria Product (CPi, j)
- Obtaining an array of Consistency Factor denoted as \lambda I and
- Calculation of Consistency Index (CI) and Consistency Ration (CR).

The below given equations illustrate the above 5 steps

$$CVij = \frac{IIij}{\sum_{i=1}^{n} IIij} \text{ For } i=1, n \text{ \& } j=1, n \quad \text{-- (1)}$$

$$CWi = \frac{\sum_{j=1}^{n} IIij}{n} \text{ For } i=1, n \text{ \& } j=1, n \quad \text{-- (2)}$$

$$CPij = CWi * CVij \text{ For } i=1, n \text{ \& } j=1, n \quad \text{-- (3)}$$

$$WSVi = \sum_{j=1}^{n} CPij \text{ For } i=1, n \quad \text{-- (4)}$$

$$\lambda i = \frac{WSVi}{CWi} \text{ For } i=1,n \quad \text{-- (5)}$$

$$CI = \frac{\lambda max - n}{n-1} \quad \text{-- (6)}$$

$$CR = \frac{CI}{CI\ std} \quad \text{-- (7)}$$

Where, λ_{max} = Maximum value of \lambda i and CIstd = Standard consistency index that depends on the number of decision factors involved. Table 8 gives the standard consistency index values for the number of decision variables present in each case of decision-making. For the application of the AHP methodology, the required criterion is that the CR value be less than 10%.

Table 8: Standard consistency index values (Sumantha Chakrabarti, 2015) [26]

N	1	2	3	4	5	6	7	8	9	10
CI_{std}	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.46	1.49

Table 9: Standard pay-off matrix (pair-wise comparison) for material selection

	UTS	YM	M	AVI	D	Sum	EEEij	Weight (RIWi)	λ
UTS	1	0.5	0.333333	0.2	0.1429	0.004762	0.343207	0.0479579	5.173125
YM	2	1	0.333333	0.2	0.2	0.026667	0.484388	0.0676858	5.254585
M	3	3	1	0.2	0.2	0.36	0.815193	0.1139107	5.39836
AVI	5	5	5	1	0.5	62.5	2.286525	0.3195067	5.298005
D	7	5	5	2	1	350	3.227109	0.4509388	5.175071
							7.15642	λ max	5.259829

- C.I – 0.064957335
- C.R – 0.058520122

Hear the value of the C.R – 0.058520122 is less than 0.1 the values which have been considered are valid Table 9 which is the Decision matrix for the selection of the material will be normalized by using the formula.
For the maximum the best (Xij/Max).
For the Minimum the best value (Min/ Xij).
The Normalized table will be as follow.

For the normalized matrix, the overall priority values will be obtained using the formula.

$$OPi = \sum_{j=0}^{m} \mathbf{Xij} * \mathbf{RIWij} \; - -(8)$$

Then for the obtained priority matrix the ranking will be given the best rank is the optimal material for the design.

Table 10: Normalized Matrix and the Calculated Priority Matrix.

Material name	Ultimate Tensile Strength	Young's Modulus	Machinability	Availability	Density	Overall priority Matrix	Rank
AISI 1018	0.785714	0.952381	0.96	0.75	0.997459	0.90066	2
AISI 4130	1	1	0.99	1	1	0.9984	1
AISI 1020	0.75	0.97619	1	0.5	0.997459	0.8255	3
Weight	0.047958	0.067686	0.113911	0.319507	0.450939		

Therefore, we can observe that in the AHP process by ranking the priority Matrix the second material which is AISI 4130 Steel, annealed at 865 C has been the optimal material for the chassis design. The detailed property of the material is mentioned in table 11 below.
Material Property.
Name: AISI 4130 Steel, annealed at 865C
Model type: Linear Elastic Isotropic
Default failure criterion: Unknown
Yield strength: 4.6e+08 N/m^2
Tensile strength: 5.6e+08 N/m^2
Elastic modulus: 2.1e+11 N/m^2
Poisson's ratio: 0.285
Mass density: 7,850 kg/m^3
Shear modulus: 8e+10 N/m^2

Table 11: Model of the go-kart chassis

Model	Design property			Centre Of mass (Cm)		
	Mass	Volume	Surface Area	X	y	z
M1	8301.91317 grams	1057.56856 cubic centimeters	10649.42443 square centimeters	-2.06071	-0.00001	-0.87606
M2	13400.72372 grams	1707.09856 cubic centimeters	10781.69703 square centimeters	-2.07928	-0.00004	-0.87222
M3	7754.73760 grams	987.86466 cubic centimeters	8655.02697 square centimeters	-2.07374	-0.00004	-0.88604

Design and analysis of the go-kart chassis

The Chassis is a very simple structural design of the main Go-Kart. The design of the Chassis is the key design of the overall design. As shown in table 3 we had selected the three modals the design of the chassis is the same but the pipe cross-section is varying the design and the simulation of these chassis is performed in the SOLIDWORKS software. [3, 7, 15, 16].

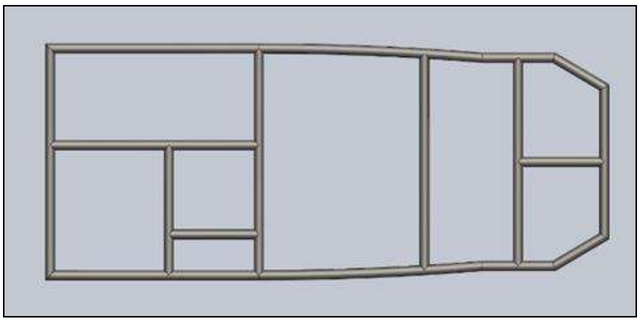

Fig 4: Ackermann steering design

The Simulation of the chassis is performed to observe the deformation that occurs in the Go-Kart Chassis. The Design analysis is performed in the following manner the simulation for the chassis is performed on the Front, Side, and Back sides [19] of the Chassis simulation is performed based on the G-force test for the simulation the 3.5g forces are considered the calculation of the force is as follow.
The Overall weight of the car is: 122.32Kg
The Value of the g is Equal to: 9.81
Therefore, force is equal to (f): 3.5*9.81*m
= 5*9.81*122.32
= 6000N

Stress and deformation analysis

The Simulation Performed to observe the Stress and Deformation of the body is used to observe the optimal Design the Force acted in the Front, Back and Side Force is acting on the design. The Design selection is performed to select the optimal design by performing the MCDM (Multi-Criteria Decision Making) the Evaluation of the Design is made by the Stress, Deformation and Mass of the Body. The mass of the chassis plays an impotent role in the design of the chassis. The Design parameters are weighted by the Entropy method. The design was selected based on the MOORA (Multi-objective optimization on the basis of ratio analysis).

Table12. The obtained simulation result are as follows

Model	Force acting	Stress		Deformation	
		MIN	MAX	MIN	MAX
M1	Front Impact	0.000e+00N/m^2	1.973e+08N/m^2	0.000e+00mm	1.107e+00mm
	Side Impact	0.000e+00N/m^2	2.670e+07N/m^2	0.000e+00mm	8.534e-02mm
	Back Impact	0.000e+00N/m^2	2.338e+08N/m^2	0.000e+00mm	1.987e+00mm
M2	fount Impact	0.000e+00N/m^3	3.146e+08N/m^2	0.000e+00mm	1.838e+00mm
	Side Impact	0.000e+00N/m^4	4.415e+07N/m^2	0.000e+00mm	1.327e-01mm
	Back Impact	0.000e+00N/m^5	3.105e+08N/m^2	0.000e+00mm	2.780e+00mm
M3	fount Impact	0.000e+00N/m^6	4.167e+08N/m^2	0.000e+00mm	2.662e+00mm
	Side Impact	0.000e+00N/m^7	4.587e+07N/m^2	0.000e+00mm	1.486e-01mm
	Back Impact	0.000e+00N/m^8	4.997e+08N/m^2	0.000e+00mm	5.090e+00mm

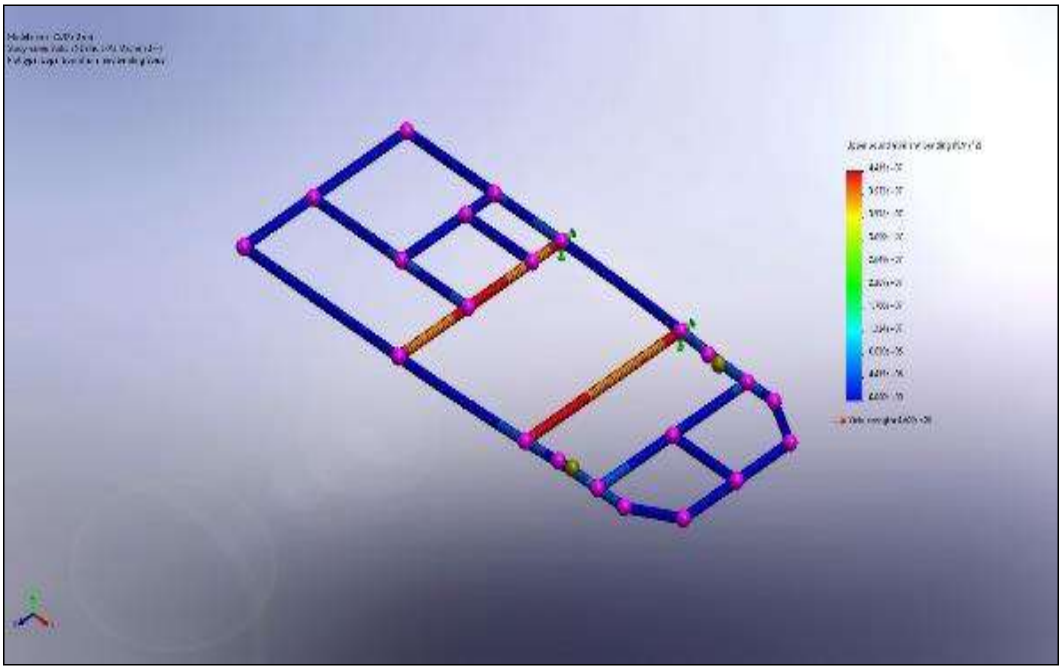

Fig 5: Stress counter in the modal-1 chassis at side impact

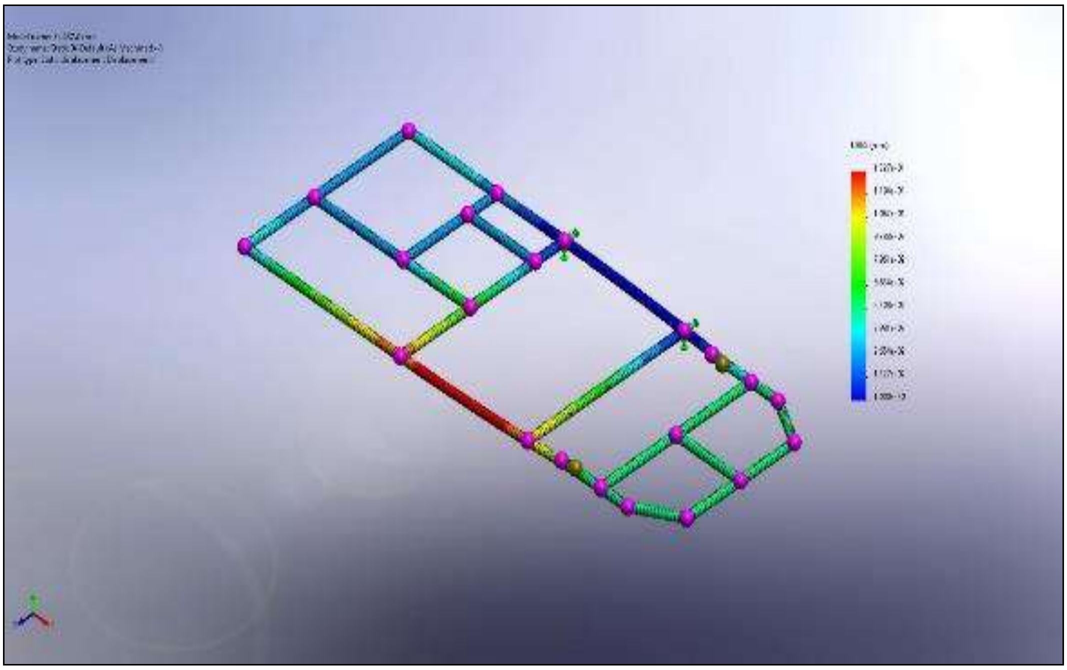

Fig 6: Deformation counter in the modal-1 chassis at side impact

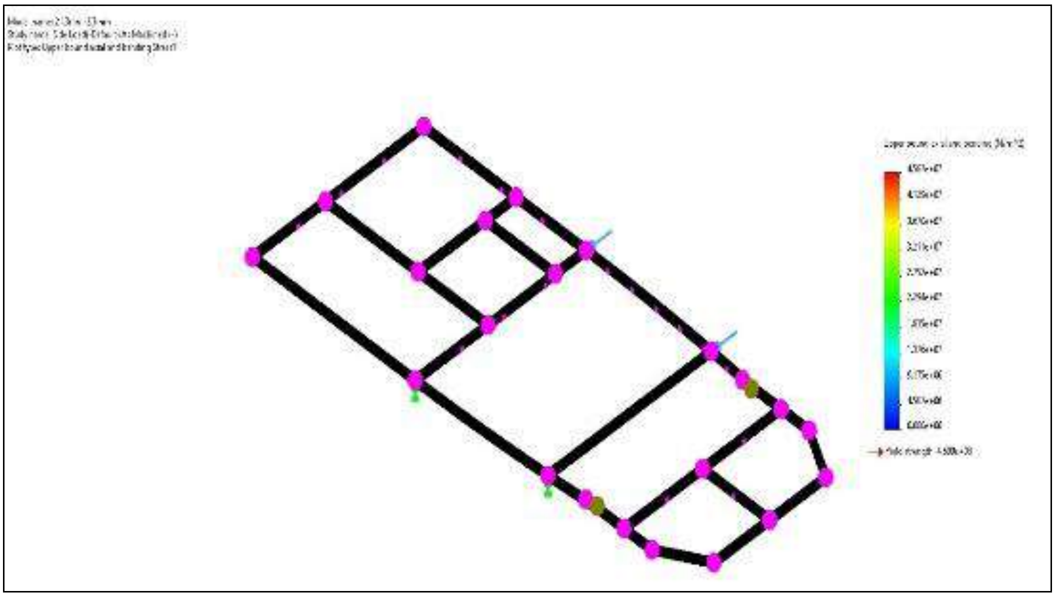

Fig 7: Stress counter in the modal-3 chassis at side impact

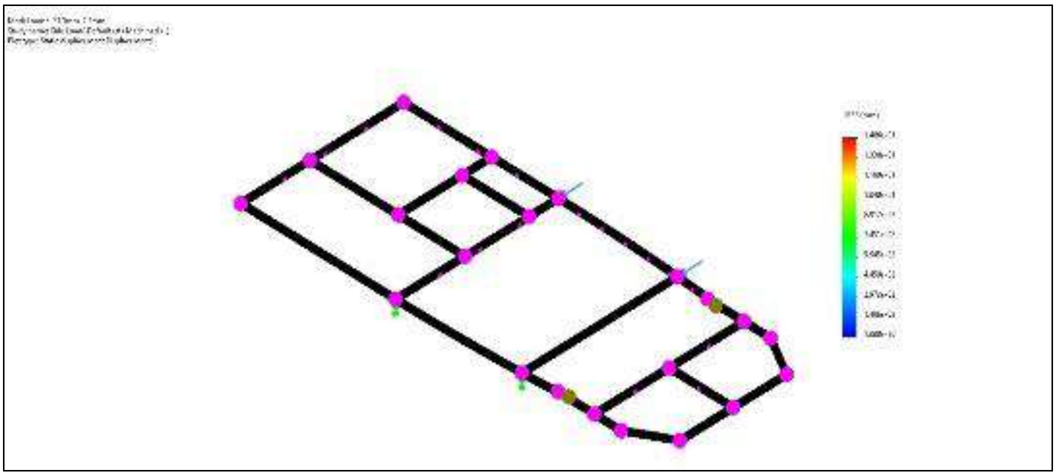

Fig 8: Deformation counter in the modal-2 chassis at side impact

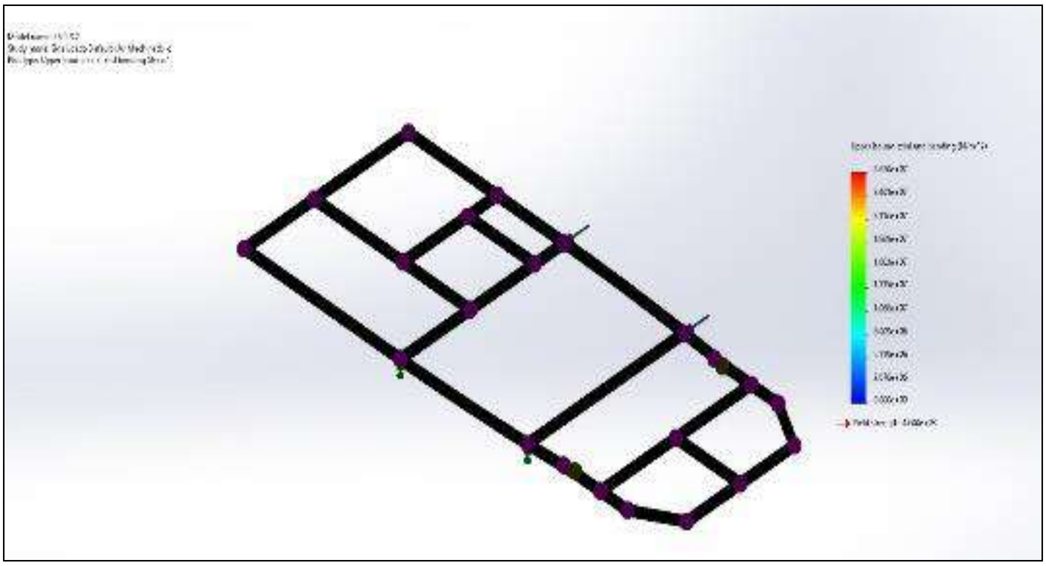

Fig 9: Stress counter in the modal-2 chassis at side impact

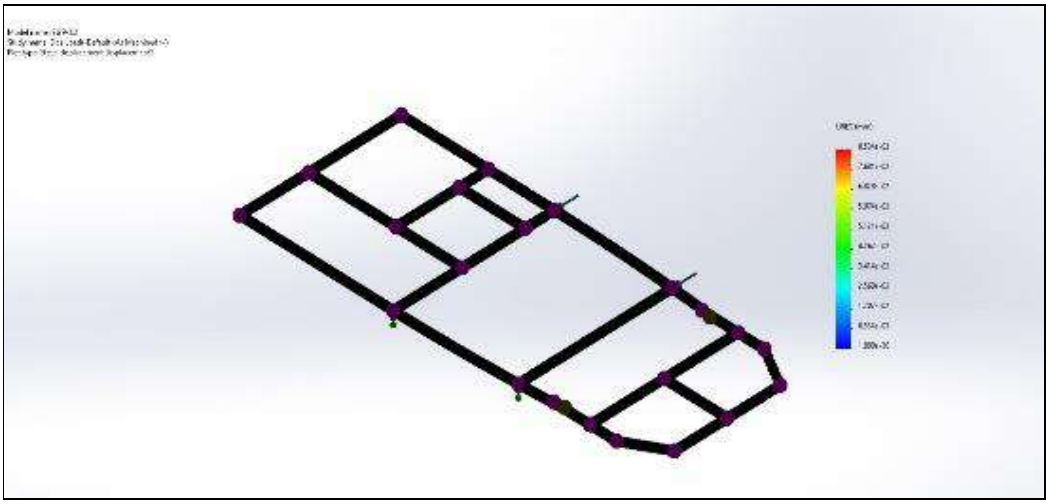

Fig 10: Deformation counter in the modal-2 chassis at side impact

Weighting the parameters based on the Entropy method
The Entropy method is used to determine the Weight of factors when the data of the decision matrix is known it was proposed by C.E. SHAMNON in 1948. It was an Objective type of weighting method. The Entropy method consists of 4 steps as follows [21].

Step1: Determine the Decision matrix with factor values for this the determined matrix is as follow.

Table 13: The Decision matrix

	Stress	MAX	Mass
M1	1.97E+08	1.11E+00	8.30E+03
	2.67E+07	8.53E-02	8.30E+03
	2.34E+08	1.99E+00	8.30E+03
M2	3.15E+08	1.84E+00	13400.72
	4.42E+07	1.33E-01	13400.72
	3.11E+08	2.78E+00	13400.72
M3	4.17E+08	2.66E+00	7754.738
	4.59E+07	1.49E-01	7754.738
	5.00E+08	5.09E+00	7754.738
$\sum_{j=0}^{m} \mathbf{Xij}$	2.09E+09	1.58E+01	8.84E+04

Step 2: In this step the normalization of the, matrix will be performed by the formula

$$Pij = \mathbf{Xij}/\sum_{i=0}^{m} \mathbf{Xij} --(9)$$

Using this formula, the normalization of the matrix is performed the Normalized table is as follow

Table 14: The Normalized matrix

Experiment	Normalized Matrix		
1	9.44E-02	6.99E-02	9.39E-02
2	1.28E-02	5.39E-03	9.39E-02
3	1.12E-01	1.26E-01	9.39E-02
4	1.51E-01	1.16E-01	1.52E-01
5	2.11E-02	8.38E-03	1.52E-01
6	1.49E-01	1.76E-01	1.52E-01
7	1.99E-01	1.68E-01	8.78E-02
8	2.20E-02	9.39E-03	8.78E-02
9	2.39E-01	3.22E-01	8.78E-02

Step 3: Computation of the Entropy measure of project outcome using the following Equation

$$Ej = -\mathbf{K}\sum_{i=1}^{m} \mathbf{Pij} * \mathbf{Ln}(\mathbf{Pij}) --(10)$$

Where the Value of the K is 1/Ln (M) = 4.55e-01
With general calculation the Matrix Pij*Ln (Pij) is named as M1
The Ej values are noted in the matrix, The Ej values are as follow

Table 15: The Entropy measures

	Stress	MAX	Mass
M1	-2.23E-01	-1.86E-01	-2.22E-01
	-5.57E-02	-2.82E-02	-2.22E-01
	-2.45E-01	-2.60E-01	-2.22E-01
M2	-2.85E-01	-2.50E-01	-2.86E-01
	-8.15E-02	-4.01E-02	-2.86E-01
	-2.83E-01	-3.05E-01	-2.86E-01
M3	-3.22E-01	-3.00E-01	-2.14E-01
	-8.38E-02	-4.38E-02	-2.14E-01
	-3.42E-01	-3.65E-01	-2.14E-01
Sum	-1.92E+00	-1.78E+00	-2.17E+00
Ej	8.74E-01	8.10E-01	9.85E-01

Step 4: Determination of the Weight's with following Equation.

$$Wj = \mathbf{1} - \mathbf{Ej}/\sum_{j=1}^{n} (\mathbf{1} - \mathbf{Ej}) --(\mathbf{11})$$

Table 16. The weighted values

Property	Ej	1-Ej	Wj
Stress	0.874325	0.125675	0.379979
MAX	0.80951	0.19049	0.575946
Mass	0.985422	0.014578	0.044076
Sum	-	0.330743	1

The Weighted Property of the Matrix is as above

- Stress – 37.9979%
- Deformation- 57.5946%
- Mass of the Chassis – 4.4076%

The Selection of the optimal Pipe Cross Section for the Chassis Material Using the MOORA

The MOORA is a method used to obtain the optimal result by separating of the Desirable and undesirable values

The Steps involved in this Method are as follow: [24]

Step 1: Obtain the Decision matrix

The Decision matrix is similar to Table 13.

Step 2: In Step 2 the normalization of the matrix will be performed based on the formula shown below then the Estimation of Assessment Values (Yi).

$$Xij * = \mathrm{Xij}/[\sum_{i=0}^{m} \mathrm{Xij}]^{1/2} - -(13)$$

$$Yi = \sum_{j=0}^{y} \mathrm{Wj} * \mathrm{Xij} - \sum_{j=y}^{n} \mathrm{Wj} * \mathrm{Xij} - -(14)$$

The First term represents the Desirable variable and the variable form y to n represent as the undesirable variables in this simulation all the parameters are undesirable variables the obtained matrix is as follow.

Table 18: The Ranking of the values.

	Xij*			Yi	Rank	Overall Ranking
M1	2.33E-01	1.31E-09	9.80E-06	-8.85E-02	4.00	1
	3.15E-02	1.01E-10	9.80E-06	-1.20E-02	1.00	
	2.76E-01	2.35E-09	9.80E-06	-1.05E-01	5.00	
M2	3.72E-01	2.17E-09	1.58E-05	-1.41E-01	7.00	2
	5.21E-02	1.57E-10	1.58E-05	-1.98E-02	2.00	
	3.67E-01	3.28E-09	1.58E-05	-1.39E-01	6.00	
M3	4.92E-01	3.14E-09	9.16E-06	-1.87E-01	8.00	3
	5.42E-02	1.75E-10	9.16E-06	-2.06E-02	3.00	
	5.90E-01	6.01E-09	9.16E-06	-2.24E-01	9.00	
Wj	0.379978704	0.575946	0.044076			

The individual experiment has been applied to obtain the individual parameters in a different direction of the force acting in a different direction. In the main ranking, the backward force on the chassis of model 1 is producing the highest rank. In the overall ranking, the M1 ranking is most optimal for the simulation of the pipe cross-section with 25.4mm * 2.0mm optimal for the Go-Kart Chassis.

The final conclusion in the design of the chassis is as follows

- By the AHP process, the selected material is AISI 4130 Steel, annealed at 865 ^{o}C.
- The Cross section of the Pipe is having the Dimension of 25.4 mm * 2.0 mm.

Conclusion

This Study the analytical study on the design and analysis of the had concluded that the In this paper the basic assumption or conditions required to design the main components to be taken under consideration are Safety, Strength, Standardization, Serviceability, Cost, Ergonomics and egress time, Driver safety, and Basic dimensions for the Design

- The Optimal diver Ergonomic has been designed for the safety and the comfort of the driver which racing in the Kart.
- The Preliminary design calculation for the design of the Go-Kart has been calculated according to the requirement of the Design.
- The steering calculation is performed for obtaining the Turning radius of the vehicle is 2 m. The track width and wheelbase are decided as 40 inches and 41.33 inches respectively for steering of Go-Kart we considered the Ackermann steering Gare mechanics.
- The breaking Calculation such as brake line pressure, clamping force, breaking force, breaking torque, rotating force, deceleration, and Stopping distance. Are calculated manually to produce an optimal condition of the go-kart.
- The Engine selected for the observation is the Bajaj Discover 125st which is 4 strokes vertical engine with the 4-value technology and which can produce a net torque of 11Nm at 7000 rpm, and the engine runs on the Gasoline and Calculation power or speed transmission by a chain over a sprocket gear the 14 teeth in the drive gear and 28 teeth in driven gear. The Transmission calculation of gear: The Torque at the wheel, velocity, and acceleration at different gears are calculated at the different gear.
- The material selection for the chassis of the Go-Kart has been performed the process of the selection of the material is based on the AHP process this was the most optimal process in the study.
- The Design of the Go-Kart chassis has been performed by using the Solid works the optimal design based upon the simulation result and the mass property of the models the stress property has been observed among the different models as said mentioned in table 10 the maximum and the minimum deformation of the material has been observed in the simulation the Figure 6 to figure 11 represent the Stress counters present in the Design which the chassis is impacted to the side load. By using the Entropy method, we determined the Weights for the factors of the simulation. From the weights obtained by the entropy method, we performed the MOORA to obtain the optimal value for the result.
- The result declares that By the AHP process the selected material is AISI 4130 Steel, annealed at 865C. The Cross section of the Pipe is having the Dimension of 25.4mm * 2.0mm.
- The bending strength of the chassis material has been obtained by using the empirical.
- This study is to obtain the optimal design of the Go-Kart in the scientifical method rather than a general approach.

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