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Material Selection in Designing and Fabrication of the Electric Go-Kart Chassis

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ABSTRACT

Car has become the most necessity of life in order to overcome the transportation needs. It is not only used for domestic purpose but it also finds its applications in commercial fields like sports. A Go-kart is a small four-wheeled vehicle which now a days mesmerize the audience in Motorsports. So, lot of research is going on to increase the strength, to make Go-kart safe and cost effective. During karting most of the Karts Chassis get deformed easily due to either weight of mountings and accessories and/or due to crash with other Karts in National Electric Kart Championship's circuit. So, research in this paper focus on the selection of Chassis materials and to fabricate based on NEKC. Kart Chassis was designed in SOLIDWORKS 2018 as per the standards of National Electric Kart Championship's design rule Book for taking part in NEKC 2018 competition as Team Ravens. And Structural analysis was also performed in SOLIDWORKS simulation on front, side and rear members of Kart during impacts and it was observed that deformation and bending stress are minimum when the kart hit the obstacle in front and deformation is maximum in rear impact and stress were maximum when Kart hit on side portion.

Keywords:— *CAD Design, Softwares, 3-D Modeling, Ergonomic, Ingress, Egress*

I. INTRODUCTION

Go-kart has no suspension and no differential. They are usually raced on scaled-down tracks but are sometimes driven as entertainment or as a hobby by non-professionals. 'Karting is commonly perceived as the stepping stone to the higher and more expensive ranks of motorsports. Kart athletics is usually accepted because the most economic variety of motorsport offered. As a free-time activity, it is often performed by nearly anybody and allowing commissioned athletics for anyone from the age of eight forward. Kart athletics is typically used as an affordable and comparatively safe thanks to introducing drivers to motor athletics.

Chassis is that the French term that was at the start want to denote the frame or main structure of a car. Chassis include all the major units necessary to propel the vehicle, direct its motion or stop it and allow it to run smoothly over uneven surfaces. It is also called a carrying unit.

The automotive chassis is tasked with holding all the parts along whereas driving and transferring vertical and lateral loads, caused by accelerations, on the chassis through the wheels. Most engineering students can have associate degree understanding of forces and torques long before they scan this [1]. Some people stress full of material choice but once you are familiar with this it is the key to a good space frame. While this will make the design better, it can still benefit from this more general design principle [2].

II. Literature Review

A chassis consists of an indoor framework that supports an artificial object in its construction and use. It is analogous to an animal's skeleton. An example of a chassis is that the body part of a motorcar, consisting of the frame (on that the body is mounted). If the running gear like wheels and transmission, and generally even the driver's seat, square measure enclosed then the assembly is delineated as a rolling chassis. The chassis takes a load of the operator, engine, brakes, equipment, and mechanism, thus chassis ought to have adequate strength to safeguard the operator within the event of an impact.

The driver cabin should have the capability to resist all the forces exerted upon it. This can be achieved either by victimization high strength material or higher cross-sections against the applied load. But the foremost possible thanks to balancing the dry mass of chassis with the optimum variety of longitudinal and lateral members. The chassis should be created of steel conduit with minimum dimensional and strength needs set by ASME.

‘Eco-Challenge’ race cars are built for fuel efficiency which means they must be lightweight and have low frictional resistance. However, they are still subjected to normal car loading such as engine and driver weight, acceleration, braking and cornering forces. The challenge is to develop a lightweight chassis that can safely withstand the required loads. In addition, the chassis must also be able to protect the driver in the event of crash [3].

Formula 1 is the top class of motorsports, demonstrating maximum race car driving performance resulting from high-tech developments in the area of lightweight materials and aerodynamic design [4].

III. Design Objectives

The chassis of a Go-Kart vehicle is either most popular to be created from hollow pipes or Super cannular section therefore on build it light-weight and shock absorbent. Chassis style ought to be such it mustn't be subjected to twist throughout sharp turns; therefore, it must have sufficient tensile and elastic enough to resist effects of centrifugal forces.

Synthesis Objectives:

- The material used in chassis should have a minimum carbon percentage of 0.18% [5].
- Minimum cross section must be 1 inch (25.4 mm), for pipe it will be OD and for rectangular section or square section, it will be its minimum height**.**
- The pipe material used for chassis must have minimum wall thickness of 1.5 mm.
- The tube/rectangular pipe used in the

fabrication of the chassis or the other frames/supports should be seamless.

- The vehicle must have a wheelbase within the range of 40 inches to 56 inches.
- The mountings and designing of chassis should be such that there should be minimum 2 inches clearances (gap) between the driver and any component of the vehicle in static and dynamic condition – hands, torso, thigh etc.
- The overall length of vehicle must be less than 76 inches and overall width must be less than 60 inches.
- The maximum height should be less than 38 inches from the ground. Holes in chassis are not permitted.
- The wheelbase of the vehicle must be within 40-56 inches and the smaller wheel track (front or rear) must be no less than 70% of the wheelbase of the vehicle.
- The weight of the chassis ought to be as low as potential. The design should allow for a driver egress of 5 seconds. The driver should have a vision of 160 degrees with 100 degrees on either side.

Following things were also considered for effective designing of the Chassis.

- Provide full protection of the driver, by obtaining required strength and torsional rigidity, while reducing weight through diligent tubing selection
- Design for manufacturability, as well as cost reduction, to ensure both material and manufacturing costs are competitive with other Go Karts.
- Improve driver comfort by providing more lateral space in the driver compartment
- Maintain ease of serviceability by ensuring that chassis members do not interfere with other subsystems.

IV. METHODOLOGY

4.1 Material Selection

The selection of material for chassis is a key factor for proper designing and fabrication. One has to be very careful while selecting the material not only considering the Strength and Maximum Load bearing resistant but also ease of welding during fabrication. After reviewing a lot of research papers AISI-1080, AISI-1020 and AISI-4130 material is choosen for doing research due to its good combination of all of the typical traits of Steel - strength, ductility, and comparative ease of machining. Various tests were performed on all above materials samples of 25.35 mm diameter with 2mm wall thickness and 50mm long. Tensile test results of all samples from the reports are presented in table 1.

For testing the material for carbon percentage and other composition, AISI-4130 sample is selected as tensile and yield strength are maximum when compared with AISI-1080 and AISI-1020. The Chemical compositions contains in a sample AISI-4130 is shown in Table 2.

Material certification is done for producing during the technical inspection. Material is certified from “Bharath Technical Labs” which is a recognized material testing laboratory for its chemical and mechanical properties, the same report is also presented at the time of inspection and throughout the event. As the values obtained in Chemical analysis and Tensile test were satisfactory so the same grade of material is utilized for full scale fabrication of chassis.

4.2 2D Design of Chassis

In order to start 3D modeling of Kart Chassis with respective to design objectives, first specifications were set roughly from standard NEKC rule book as given below. And 2D drafting of Chassis with selected design parameters was done in AutoCAD 2017 Software as shown in Figure 1.

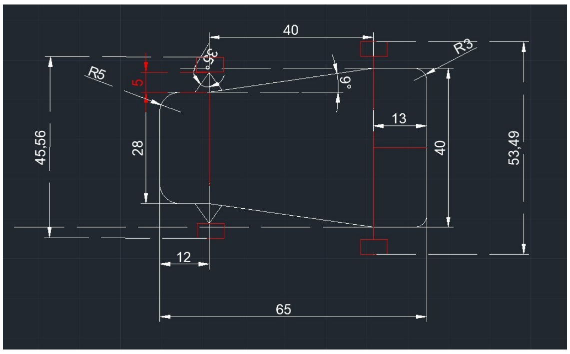

Figure 1: 2D Chassis with dimension

Wheelbase

The wheelbase of the kart is within the limits prescribed in the rule book i.e. 40"-56”. The kart has the wheelbase of 50” from the point of contact of the ground of front tire to point of contact of the ground of rear tire.

Track width

The larger track width of the kart is 60” and the smaller track width is 50”. The kart has smaller front track width and larger rear track width; which satisfies the condition mentioned in rule book i.e. The smaller track of the vehicle (front or rear) should be 50 but seventy-fifth of the larger track.

Table 1: Tensile Test Report Data.

Identity of Sample	**1” OD X 2.00mm Wall Thk Seamless Pipe**		
Mechanical Test Results			
	AISI-1080	**AISI-1020**	**AISI-4130**
<u>Tensile Test</u> OD X ID of Test Bar, mm	25.35 x 21.01	25.35 x 21.01	25.35 x 21.01
Area, mm^2	158.09	158.09	158.09
Initial Gauge Length, mm	50	50	50
Yield Load, N	42072	32290	58320
Maximum Load, N	52720	40461	73080
Final Gauge Length, mm	63.31	60.215	68.45
Yield Strength, N/mm^2 (Mpa)	290.8	230.6	368.9
Tensile strength, N/mm^2 (Mpa)	342.7	290.5	462.3
%Elongation	26.62	20.43	36.90

Table 2: Chemical Analysis Report Data

Identity of Sample	**AISI-4130, 1” OD X 2.00mm Wall Thk** Seamless **Pipe**					
Chemical Composition in %						
C	**Mn**	**Si**	**S**	**P**	**Ni**	**Cr Mo**
0.18	0.61	0.21	0.011	0.018	0.012	0.014 <0.005

Overall Width

The width of the kart is 58” from one end of the rear tire to another tire which has the larger wheel track. This width includes the side bumpers and all the four tires and the bumpers in the front and rear.

Overall Length

The overall length of the kart is 68” which satisfies the rulebook which mentions that the maximum length must be 76”. The overall length of this kart includes the front and rear bumpers.

4.3 3D Modeling of Chassis

2D drafting of Chassis was finalized after doing some modifications and it was converted into 3D model. 3D Modeling of kart Chassis was done in SOLIDWORKS 2018 ver as a 3D modeling software package in CAD/CAM lab College premises as shown in Figure 2. Using this style software package allowed the team to check the planning in the 3-D area and scale back errors in fabrication. The other main criterion in chassis design was to achieve a perfect balance between a spacious and ergonomic driver area with easy ingress and egress, and compact dimensions to achieve the required weight and torsional rigidity criteria. Following this criterion, the specified dimensions were still roughly set employing a virtual template to realize the required clearances just in case of a change scenario.

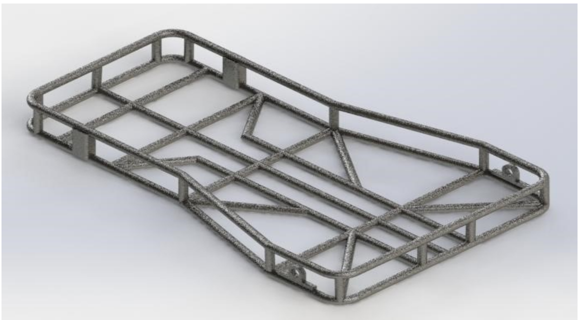

Figure 2: 3D Image of Chassis with cross members

4.4 Analysis

The design made in SOLIDWORKS is tested in the same software without much cross members using simulation. Load is applied on front members of structure keeping the side and rear members as fixed constrained in first case in order to check the deflection and stresses. Similarly, load is also applied on side members in second case keeping the front and rear members fixed. In the last case load were applied on rear members making the front and side faces of members as fixed.

Deflection results when the load applied on front portion of Chassis obtained in simulation is shown in figure 3 and deflection results in case 2 and case 3 is shown in figure 4 and figure 5 respectively. When these three cases compared with each other under defection criteria, it is observed that deflection is very less in first case i.e., 1.34mm and maximum in rear i.e., 5.91mm, 4.66mm in side portion.

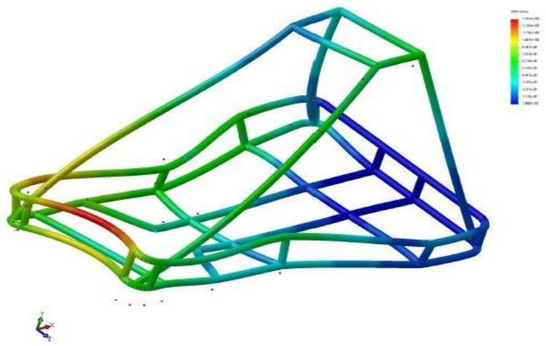

Figure 3: Deflection under Front load

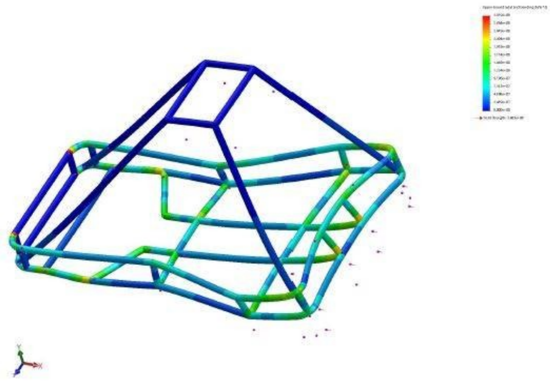

Figure 4: Deflection under Side load

Bending Stresses occurred during impact load on front faces is shown in figure 6 and stresses in case 2 and case 3 were also shown in figure 7 and figure 8 respectively. It was observed that bending stress is maximum when the load is applied on side members i.e.,3247 N/m^2 and less in front portion 2449 N/m^2 and 2939 N/m^2 in rear portion of Chassis.

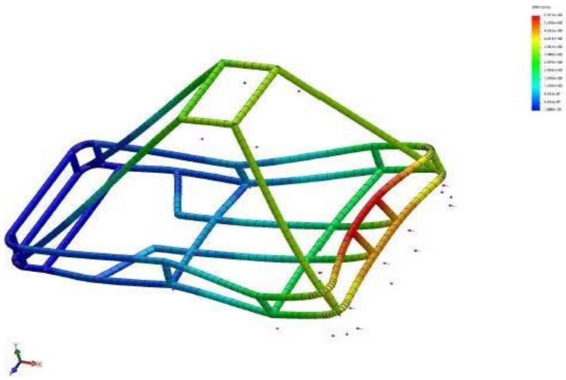

Figure 5: Deflection under Rear load

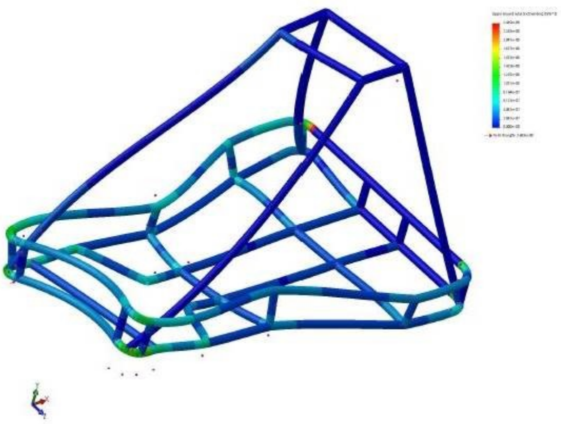

Figure 6: Bending Stress under Front load

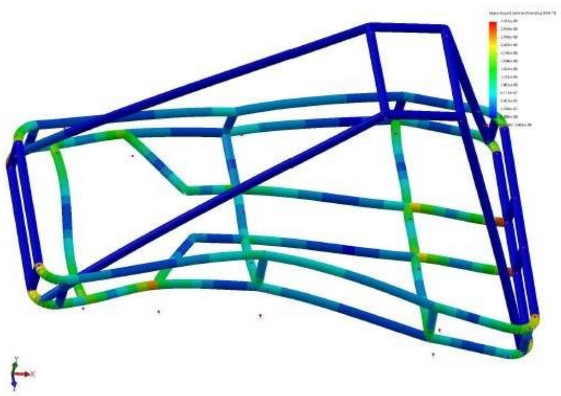

Figure 7: Bending Stress under Side load

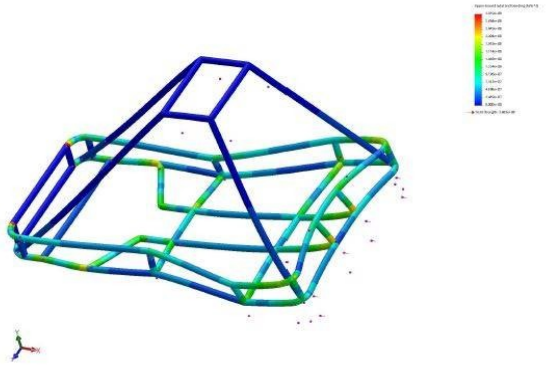

Figure 8: Bending Stress under Rear load

The results in the simulation were not satisfactory specifically when the load applied on side members. This is due to absence of the cross members, so modifications in design were done and more cross members were included to support and strengthen the structure as shown in Figure 11.

4.5 Fabrication of Chassis

The pipes were formed in the shape using 6m pipes each. The chassis is a Tubular Space Frame type. This type has been adapted and used for its rigidity, strength and its ability to absorb impacts with lesser damage. This chassis was bent using bending machine and then the parts were welded together one by one using arc welding and then additional cross members were added for extra strength as shown in figure 9 and figure 10.

Figure 9: Chassis Rod Welding

Figure 10: Pipes Bend for In-process Chassis

When the welding was completed, the grinding work was done for the finishing the work and the Emery papers were used to get rid of any rust or stains.

Figure 11: Fabricated Chassis

Figure 12: Chassis with Sheet for Cockpit

The frame members joining at right angles are mitered at an angle of 45 degree. The diagonal ones are mitered to the requirement of the joint being made. Welding is done on all the members and making sure that every joint should be a complete one and no holes be left unfilled in the frame, which ensures that the strength of the frame is not compromised. Complete fabricated Chassis without sheet and with sheet is shown in figure 11 and figure 12 respectively.

The rear axle is mounted to the frame through bearings on a bearing carrier bolted to a plate. The plate is welded on to the frame this is done to avoid any possible weakening of the frame. Hubs carrying each the sprocket and also the rotor area unit mounted onto it. The hubs are anchored on to the shaft using bolts with the help of a key to enhance the torque transmission.

A hub was mounted on the front axle to carry the wheel. To enhance the safety in case the nut loosens a jam nut was added to make sure the hub was securely in place. The wheels were chosen according to their availability and the clearance they could offer thus enhancing the stability of kart. The wheels are threaded which allows the car to be used on an all-weather road.

Similarly, Steering System, Driver's seat, motor, motor controller, four lead-acid batteries, braking system, Electric wires and other accessories were also mounted and fitted securely on to the frame to complete the Kart.

V. Results and Discussion

Material selection for Chassis designing and fabrication was not less than challenging with respect to material strength and other mechanical and chemical properties. After under-going the mechanical and chemical analysis test of samples made of AISI-1020, AISI-1080 and AISI-4130, it is cleared from the reports that, AISI-4130 has maximum tensile strength i.e., 462.3Mpa and less strength in AISI-1020 with 290.5Mpa and 342.7Mpa in AISI-1080. And with respect to other properties and ease of fabrication, AISI-4130 alloy is selected during analysis and fabrication for the robust Chassis.

Once the material was selected, simulation was carried out. It was crucial to find out the deformation in the Chassis under application of impact load on various portions of Chassis and stresses induced in it. It was observed that the deformation in less when the load applied on front members of Chassis i.e., 1.34mm and more when it is subjected to load on rear members i.e., 5.91mm and 1.25 lesser in side impact when compared with rear impact case.

Bending stress occurred in Chassis is minimum in front case i.e., 2449 N/m^2 and maximum in side members i.e., $3247N/m^2$. This is due to the smaller number of cross members. Lastly, on the rear portion, bending stress observed is $2939N/m^2$, which is $308N/m^2$ less than the side impact and $490N/m^2$ greater than the front impact loading.

After considering the results obtained in simulation, Extra cross members were included and Chassis was modified to overcome stresses occurring in side portion. Finally, Chassis is fabricated easily using arc welding process.

VI. CONCLUSION

To conclude, AISI-4130 material is excellent for Chassis fabrication as it has more strength when compared with AISI-1020 and AISI-1080 based on the results obtained after tensile testing of samples. Chemical composition in AISI-4130, specifically carbon content is sufficient enough i.e., 0.18% for selecting the material, which is observed from the chemical analysis report.

Deflection and bending stresses were comparatively less in front of the Chassis when compared with side and back of Chassis i., e 1.34mm and $2449N/m^2$ respectively. Deflection is more in rear Chassis but less stresses when compared with front and side impacts. Maximum stresses were observed during side impact loading i., e $3247N/m^2$.

Chassis were fabricated with the AISI-4130 material and based on design rule book parameters. Extra cross members were included after evaluation of results from simulation to avoid inducing of stresses in side portion. This makes high Strength Chassis, which can now bear the weight of all mountings and accessories including driver.

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