DESIGN AND STATIC ANALYSIS OF A GO-KART CHASSIS

A Project report submitted

in partial fulfilment of the requirement for the award of the degree of

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In

MECHANICAL ENGINEERING

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ABSTRACT

A go-kart, often referred to as a kart is a type of open-wheel car. It is a small four-wheel vehicle used for traditional go-kart racing and amusement purposes. They resemble the formula cars but are not as swift as they are. Moreover go-karts are cheaper than any other racing vehicle. Many recreational karts can be powered by four-stroke engines or electric motors, while racing karts use a two-stroke or, rarely, higher powered four-stroke engines. Most of them are single seated vehicles, but some recreational models can accommodate a passenger.

This project is aimed at modelling and performing the static analysis of a go-kart chassis which is usually constructed using circular beams. The main objective of the design is to make the chassis durable as well as reliable. The frame also needs to be rigid and torsion free. In addition to these basic requirements, the driver safety also has been kept in consideration. This means that the frame will be able to withstand larger forces, thereby causing minimum deformation and hence, lesser impact on the driver.

The major portion of the design process is to do modelling and perform analysis of the go-kart chassis by using 3D simulation software like SOLIDWORK. This software helps in the conceptualisation of the design until the final manufacturing of the product. It also lends several benefits like shortened design cycle and increased productivity.

The analysis was performed by considering the frame to be made of AISI 1020. The results from this material were taken into consideration as the frame made up of AISI 1020 could yield better results based on the parameters like strength to weight ratio, high tensile strength and machinability, price and availability.

KEYWORDS: Chassis, Cockpit, Orthographic View, Collision, Impact, Simulation, Modelling, Optimisation

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CHAPTER-1

INTRODUCTION

1.1 GO-KART

Go-kart is a simple four-wheeled, small engine, single Seated racing car. They were initially created in the 1950s, Post-war period by airmen as a way to pass spare time. Art Ingles is generally accepted to be the father of karting. He built the first kart in Southern California in 1956. From then, it is being popular all over America and also in Europe. A Go-kart, by definition, 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 motor sports. Kart racing is generally accepted as the most economic form of motor sport available. As a free-time activity, it can be performed by almost anybody and permitting licensed racing for anyone from the age of 8 onwards. Kart racing is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. Many people associate it with young drivers, but adults are also very active in karting.

Go-Kart is a great outlet for those interested in racing because of its simplicity, cost and safer way to race. The tracks go-kart is similar to F1 racing track. A go-kart is powered by 125cc engine in most of the countries. In some countries, go-karts can be licensed for use on public roads. Typically, there are some restrictions, e.g. in the European Union a go-kart on the road needs head light (high/low beam), tail lights, a horn, indicators and a maximum of 20 HP.

In a Go-Kart, there are mainly six parts. They are:

1. Chassis
2. Engine
3. Steering
4. Transmission
5. Tyres
6. Brake

1.1.1 CHASSIS

A vehicle frame, also known as its chassis, is the main supporting structure of a motor vehicle, to which all other components are attached, comparable to the skeleton of an organism. Until the 1930s virtually every car had a structural frame, separate from its body. This construction design is known as body-on-frame. Over time, nearly all passenger cars have migrated to unibody construction, meaning their chassis and bodywork have been integrated into one another. Nearly all trucks, buses, and most pickups continue to use a separate frame as their chassis.

The main functions of a frame in motor vehicles are:

1. To support the vehicle's mechanical components and body
2. To deal with static and dynamic loads, without undue deflection or distortion.

These include:

- Weight of the body, passengers, and cargo loads.
- Vertical and torsional twisting transmitted by going over uneven surfaces.
- Transverse lateral forces caused by road conditions, side wind, and steering the vehicle.
- Torque from the engine and transmission.
- Longitudinal tensile forces from starting and acceleration, as well as compression from braking.
- Sudden impacts from collisions.

Types of frame according to the construction:

- Ladder type frame
- X-Type frame
- Off set frame
- Off set with cross member frame
- Perimeter Frame

The chassis of go-kart was designed on the parameters to guide complete safety of rider as well as to maintain the feasibility of go-kart for all loads applicable. The loads that are applicable on the chassis are studied under various considerations like go-karts spring mass load, Cornering forces, impact forces, torsional rigidity and the overall dynamic loads applied during running conditions. The thereby was designed to rider safe and to combat the loads applied on it without compromising the structural strength.

The design section of this report is broken into four major topics

1. The design objectives
2. The design calculations
3. Analysis & Modifying
4. Testing
5. Finalizing

Based on the overall design objectives of Safety, strength and light weight the design team must meet all of the criteria by the design team and must meet all of the requirements to become a part of overall successful design alternatives were also considered during each process.

1.1.2 ENGINE

Amusement park go-karts can be powered by four-stroke engines or electric motors, while racing karts use small two-stroke or four-stroke engines. Four-stroke engines can be standard air-cooled industrial based engines, sometimes with small modifications, developing from about 5 to 20 hp. Briggs & Stratton, Tecumseh, Kohler, Robin, and Honda are manufacturers of such engines. They are adequate for racing and fun kart applications. There are also more powerful four-stroke engines available from manufacturers like Yamaha, TKM, Swiss auto or Aixro (Wankel engine) offering from 15 hp up to 48 hp. They run to and around 11,000 rpm, and are manufactured specifically for karting

Fig 1.1- Go-Kart Engine

Two-stroke kart engines are developed and built by dedicated manufacturers. WTP, Comer, IAME (Parilla, Komet, Woltjer), TM, Vortex, Titan, REFO, Modena Engines, TKM, PRD, Yamaha and Rotax are manufacturers of such engines. These can develop from about 8 hp for a single-cylinder 60 cc unit (MiniROK by Vortex) to over 90 hp for a twin 250 cc. Today, the most popular categories worldwide are those using the TaG 125 cc units. The recent 125 cc KF1 engines are electronically limited at 16,000 rpm. Most are water-cooled today; however, previously air-cooled engines dominated the sport.

1.1.3 STEERING

Steering is the collection of components, linkages, etc. which allows any vehicle (car, motorcycle, bicycle) to follow the desired course. An exception is the case of rail transport by which rail tracks combined together with railroad switches (and also known as 'points' in British English) provide the steering function. The primary purpose of the steering system is to allow the driver to guide the vehicle.

The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints (which may also be part of the collapsible steering column design), to allow it to deviate somewhat from a straight line. Other arrangements are sometimes found on different types of vehicles. Tracked vehicles such as bulldozers and tanks usually employ differential steering—that is, the tracks are made to move at different speeds or even in opposite directions, using clutches and brakes, to bring about a change of course or direction.

Fig 1.2- Steering Mechanism of a Go-Kart

1.1.4 TRANSMISSION

Karts do not have a differential. The lack of a differential means that one rear tire must slide while cornering; this is achieved by designing the chassis so that the inside rear tire lifts up slightly when the kart turns the corner. This allows the tire to lose some of its grip and slide or lift off the ground completely. Power is transmitted from the engine to the rear axle by a chain. Both engine and axle sprockets are removable; their ratio must be adapted to the track configuration in order to get the most from the engine.

In the early days, karts were direct drive only (requiring push starts), but the inconvenience of that setup soon led to the centrifugal clutch for the club level classes. Dry centrifugal clutches are now used in many categories (Rotax Max is one example) and have become the norm as the top international classes have switched to 125 cc clutched engines.

Fig 1.3- Transmission of a Go-Kart

1.1.5 TYRES

Wheels and tires are much smaller than those used on a normal car. Rims are made of magnesium alloy, aluminium, or composite materials. Tires can support cornering forces in excess of 2 g (20 m/s^2), depending on chassis, engine, and motor setup. Some car tire manufacturers, such as Bridgestone, Dunlop, and Maxxis make tires for karts. There are also specific kart tire manufacturers, which include MG, MOJO, Vega, Hoosier and Burris. Similar to other motorsports, kart tires have different types for use appropriate to track conditions:

Slicks, for dry track. Slick kart tires come in many different compounds, from very soft (maximum grip) to very hard (amusement and rental karts, less grip but long life span). In international level racing, because the drivers are free to choose their tires and because of the short duration of each round (10 to 20 minutes maximum), these are some of the softest tires found in motorsport. Rain tires, or "wets", for wet weather. They are grooved, made of soft compound, and are narrower than slicks. Not all racing classes allow rain tires.

Fig 1.4- Go-Kart Tyres

Special, such as spiked tires for icy conditions, or "cuts/grooved" for high grip dirt/clay speedways. Cuts are slicks modified with a lathe to optimize handling. Tire manufacturers such as Hoosier and Burris also make a slightly larger grooved tire only used in dirt track racing.

1.1.6 BRAKES

A brake is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished by means of friction.

Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat, though other methods of energy conversion may be employed. For example, regenerative braking converts much of the energy to electrical energy, which may be stored for later use. Other methods convert kinetic energy into potential energy in such stored forms as pressurized air or pressurized oil. Eddy current brakes use magnetic fields to convert kinetic energy into electric current in the brake disc, fin, or rail, which is converted into heat. Still other braking methods even transform kinetic energy into different forms, for example by transferring the energy to a rotating flywheel. Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

Fig 1.5- Go-Kart Brakes

1.2 SOLID WORKS

SolidWorks is a solid modelling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs on Microsoft Windows. SolidWorks is published by Dassault Systèmes.

SolidWorks Corporation was founded in December 1993 by Massachusetts Institute of Technology graduate Jon Hirschtick. Hirschtick used $1 million he had made while a member of the MIT Blackjack Team to set up the company. Initially based in Waltham, Massachusetts, United States, Hirschtick recruited a team of engineers with the goal of building 3D CAD software that was easy-to-use, affordable, and available on the Windows desktop. Operating later from Concord, Massachusetts, SolidWorks released its first product SolidWorks 95, in November 1995. In 1997 Dassault, best known for its CATIA CAD software, acquired SolidWorks for $310 million in stock. Jon Hirschtick stayed on board for the next 14 years in various roles. Under his leadership, SolidWorks grew to a $100 million revenue company. SolidWorks currently markets several versions of the SolidWorks CAD software in addition to e-Drawings, a collaboration tool, and Draft sight, a 2D CAD product.

1.2.1 MODELLING

SolidWorks is a solid modeller, and utilizes a parametric feature-based approach which was initially developed by PTC to create models and assemblies. The software is written on Parasolid-kernel. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allows them to capture design intent.

Design intent is how the creator of the part wants it to respond to changes and updates. For example, you would want the hole at the top of a beverage can to stay at the top surface, regardless of the height or size of the can.

Features refer to the building blocks of the part. They are the shapes and operations that construct the part. Shape-based features typically begin with a 2D or 3D sketch of shapes such as bosses, holes, slots, etc. This shape is then extruded or cut to add or remove material from the part. Operation-based features are not sketch-based, and include features such as fillets, chamfers, shells, applying draft to the faces of a part, etc.

Building a model in SolidWorks usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity. The parametric nature of SolidWorks means that the dimensions and relations drive the geometry, not the other way around. The dimensions in the sketch can be controlled independently, or by relationships to other parameters inside or outside of the sketch.

1.2.2 ASSEMBLY

In an assembly, the analog to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies. SolidWorks also includes additional advanced mating features such as gear and cam follower mates, which allow modelled gear assemblies to accurately reproduce the rotational movement of an actual gear train.

SolidWorks files (previous to version 2015) use the Microsoft Structured Storage file format. This means that there are various files embedded within each SLDDRW (drawing files), SLDPRT (part files), SLDASM (assembly files) file, including preview bitmaps and metadata sub-files. Various third-party tools (see COM Structured Storage) can be used to extract these sub-files, although the sub files in many cases use proprietary binary file formats.

1.2.3 SIMULATION

SOLIDWORKS Simulation linear stress analysis allows designers and engineers to validate product quality performance and safety throughout the design creation. Solid Works Simulation integrates seamlessly with the design process, allowing you to run linear stress analysis directly from your Solid works CAD model resulting in fewer costly prototypes, reduced rework and delays and greater time and cost efficiency.

Using linear stress analysis, calculate geometry stress and deformation with three basic assumptions:

- The selected part or assembly under load will deform with small rotations and displacements
- Any product loading will remain static (ignoring inertia) and stay constant over time
- The material has a constant stress / strain relationship (Hooke's Law)

SOLIDWORKS Simulation utilises finite element analysis (FEA) method in order to discretise design components down into solid, shell or beam elements, using linear stress analysis to define the response of parts and assemblies when applied to the effect of:

- Forces
- Pressures
- Accelerations
- Temperatures
- Contact between components

Loads can be imported from a variety of studies including thermal, flow and motion in order to run multi-physics analysis. When running a stress analysis component data is key, the Solid works material database is prepopulated with materials ready for use within Solid works Simulation and can be easily customised to meet any specific material requirements.

1.3 MATERIAL

The frame is constructed using a steel space frame design. Considering strength to weight ratio, price and availability of roll cage materials, we used circular tubes of AISI 1020 with dimensions 1in OD and 3mm thickness. Thick 1in pipes were used rather than thin 1.5 in pipes. 1020 was preferred over MS because of its low weight to strength ratio, high yield, and ultimate bending strength. With above considered aspects with AISI 1020, the weight of the chassis was optimized to ~20Kg.

S.No	Properties	Values
1.	Tensile strength Ultimate	394720000N/m²
2.	Tensile strength Yield	294740000N/m²
3.	Bulk modulus	140 GPa
5.	Modulus of elasticity	2.05e+011 N/m²
6.	Poisson's ratio	0.285 N/A

The chemical composition of the material is as

- Carbon C = 0.18%-0.20%
- Manganese Mn = 0.30%-0.60%
- Phosphorous P = 0.040% (max)
- Sulphur S = 0.05% (max)

CHAPTER-2

LITERATURE REVIEW

The aim of this chapter is to provide, through some selective reference of the literature cited, a clear understanding of different ways in which a go-kart chassis was designed and other analytical investigations on the frame that were done previously. These technical publications and journals published in national and international levels helped us in enhancing the progress of our work.

Previous Research Papers Cited

- **Simranjeet Singh** et al. [1] stated that their main objective of the design was 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.

- **Shaik Himam Saheb** et al. [2] stated that their paper concentrated on explaining the design and engineering aspects of making a Go Kart. This report explained objectives, assumptions and calculations made in designing a Go Kart. The team's primary objective was to design a safe and functional vehicle based on rigid and torsion free frame. The design was chosen such that the Kart is easy to fabricate in every possible aspect.

- **Dr.D.Ravikanth** et al. [3] stated that in India go-karting is getting ready to make waves. A racing track is ready in Nagpur for go-karting and Chennai is also trying to make one. Indian companies are also producing go-karts in small scale. MRF and Indus motors are the major bodies in karts and they are offering karts between 2 lakh and 3 lakh. But to make go-karts popular, the price must come down. For that, many people are trying to build one under 1 lakh and we had also take up the challenge and make our under 78 K. This is a dream come true. A go-kart just under ₹100000/-. So we are sure that our project will have a high demand in the industry and also we are hoping to get orders from the racing guns.

- **Koustubh Hajare**, et al. [4] stated that their paper was aimed at the design analysis of a go kart chassis. The main intention was to do modelling and static analysis of go-kart chassis. The maximum deflection was obtained by analysis. The go-kart chassis are different from chassis of ordinary cars on the road. The paper highlighted the material used and structural formation of chassis. The strength of material, rigidity of structure and energy absorption characteristics of chassis was discussed. The modelling and analysis were performed using 3-D software such as SOLIDWORKS & ANSYS

- **Mr.Virendra.S.Pattanshetti** et al. [5] stated that they have made the 3D model of Go Kart and Roll Cage in Catia-V5. Roll Cage comes under the sprung mass of the Vehicle. There were a lot of forces acting on vehicle in the running condition. These forces were responsible for causing crack initiation and deformation in the vehicle. Deformation results in Stress Generation in the Roll Cage. Hence it is important to find out these areas of maximum Stresses. In this paper an attempt is made to find out these areas by carrying out FEA of the Roll Cage. They have carried out Crash Analysis (Front and Side Impact), Torsional Analysis. All these Analysis have been carried out in Hyper Works 11.0.

- **Ujjal Kalita** et al. [6] stated that the main motive of their vehicle was driver safety. The vehicle has been designed in such a way that it can carry up to a 95th percentile male. Along with that vehicle reliability is not compromised in the pursuit of speed. Chassis was of a tubular cross section pipe, fabricated assembly of AISI 1020 grade and a few other grades. In this kart, they have used AISI 1020 class tube with 1 inch diameter and 2 mm wall thickness. A front and side impact test was also simulated for the design to ensure the safety of the driver. Frame gussets were also added in strategic locations in order to brace weak members or members that can experience high loading. Front and rear bumpers were also added to protect the vehicle in the event of front or rear impact.

- **D.Raghunandan** et al. [7] stated that their paper aimed to model and perform the dynamic analysis of the go-kart chassis which is of constructed with circular beams. Modelling and analysis are performed in SOLIDWORKS and ANSYS respectively. The go-kart chassis is different from ordinary car chassis. The chassis is designed in such a way that it requires less materials and ability to withstand loads applied on it. Strength and light weight are the basic consideration for choosing the chassis material. AISI 1018 is the suitable material to be used for the go-kart chassis

- **Mr. Kartik Kelkar** et al. [8] stated that their paper was aimed at modelling the static analysis of go-kart chassis consisting of circular beams. Modelling and analysis are performed using 3-D modelling software i.e. CATIA & static analysis in ANSYS 14.5. The maximum deflection is obtained by analysis. The go-kart chassis are different from the chassis of ordinary cars on the road. The material used and structural formation of chassis. The loads are applied to determine the deflection of chassis.

- **Harish Harsurkar** et al. [9] stated that Go-karts come in all shapes and forms, from motor less models to high-powered racing machines, some, like Super karts, being able to beat racing cars on long circuits. Analysis is performed on Go-Kart basically for weight reduction and testing the designed components. Front Impact, Rear impact, Side impact and torsion analysis is performed on the chassis. Other components of Go kart are also analysed for better factor of safety and weight reduction.

CHAPTER-3

THEORETICAL ANALYSIS

3.1 OBJECTIVE OF FRAME DESIGN

The frame is designed to meet the technical requirements of competition. The role of the frame is to fit all components of the kart, including a driver, efficiently and safely. Principal aspects of the chassis focused on during the design and implementation included driver safety, transmission. The number one priority of the chassis design was driver safety and next comes engine safety.

The frame was divided into the two major boxes front box (cockpit) for steering and seat positions and rear box both the blocks are separated by a firewall Different chassis models are made. The overall size and weight of the models were compared further all the models on the basis of strength to withstand all possible impacts by proper FEA for front impact, side impact. Rear impact and also by applying all inertial forces in chassis.

3.1.1 FRAME SAFETY

Structural integrity of the frame was verified by comparing the analysis result with the standard values of the material. Theoretical calculated loads were placed on a wireframe model of the frame at critical points to simulate the amount of force that the vehicle would undergo from its own weight and the driver in the event of collision. Analysis was conducted by use of Simulation in Solid Works. To conduct Simulation of the chassis a design of chassis was uploaded from the computer stresses were calculated by simulating three different induced load cases .The load cases simulated were frontal impact, side impact, rear impact and Torsion analysis.

3.1.2 STRUCTURAL RIGIDITY

Overall frame structural rigidity is important to enhance the capabilities of a 4-wheeler vehicle. To measure the overall frame rigidity, tensional rigidity analysis was conducted through simulation. The objective of the tensional rigidity analysis was to manipulate the chassis design within the SolidWorks software to increase the amount of torque per degree of chassis deflection. By theoretically increasing this value, the actual vehicle could have the ability to be more torsion-ally rigid, making it able to withstand more intensive without failure.

3.1.3 WEIGHT

Keeping the frame as light as possible was a top priority. When power is limited, vehicle weight is a large factor in vehicle performance. The frame is one of the largest and heaviest components of the car, and which is why special attention was placed on the vehicle's frame weight. The strategy utilized to minimize weight consisted of determining defined goals for the chassis and employing the correct material in the best places to accomplish those goals. Once Baseline safety design requirements were met, FEA aided the material decision making process.

Solid works simulation specifically helped to determine whether a member was under high or row stresses, in the scenarios discussed previously, making the chassis design process efficient and effective. Chassis members were made out of 0118 inch (3mm) wall thinness and 1 inch (25.4mm) outer diameter AISI 1020, this material was chosen because of its weight reduction capability and beneficial material properties, as was stated previously. Through accurately determining stresses on the chassis in different scenarios, weight reduction was able to be maximized through material selection and placement also the simplicity of the frame design that is use of less number of members tends to reduction in the weight.

CHAPTER-4

DESIGN PROCEDURE AND ANALYSIS

4.1 DESIGN OF "THE CRAB FRAME"

Go-karts are fun ride adventure vehicles and are prone to more accidents than any other vehicles. As we started off our project, we were oriented towards making a frame which would be the safest and wouldn't intervene between fun and driver's safety. So, basing on many designs from our references, we made a frame which was which we expected to be very strong. We named it "The Crab Frame" as it appeared a lot like crab.

Fig 4.1(a), Fig 4.1(b), Fig 4.1(c) depict the dimensions of the chassis which was designed initially. The length of the chassis was taken as *77.16 inch*. The tail length was taken as *20.07 inch* and the width of the frame at the bumper was taken as *54.33 inch*. The bumper was again divided into three parts. The end parts of length *16.92 inch* each which were a bit inclined to the horizontal and the centre part of length *20.07 inch* which was along the horizontal. The bumper was actually a combination of three pipes which totally comprised a height of *5.90 inch*.

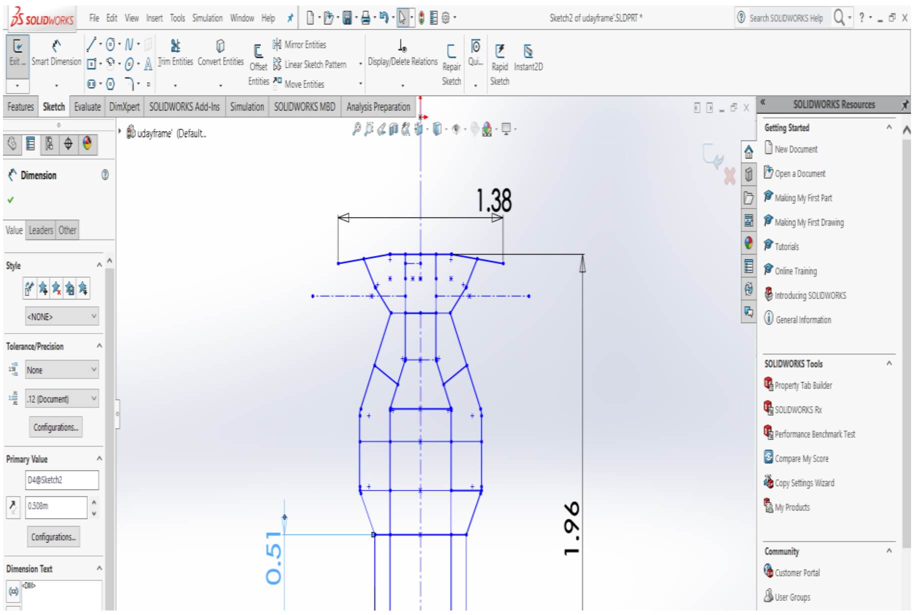

Fig 4.1(a) - Modelling of "The Crab Frame" (Dimension-I)

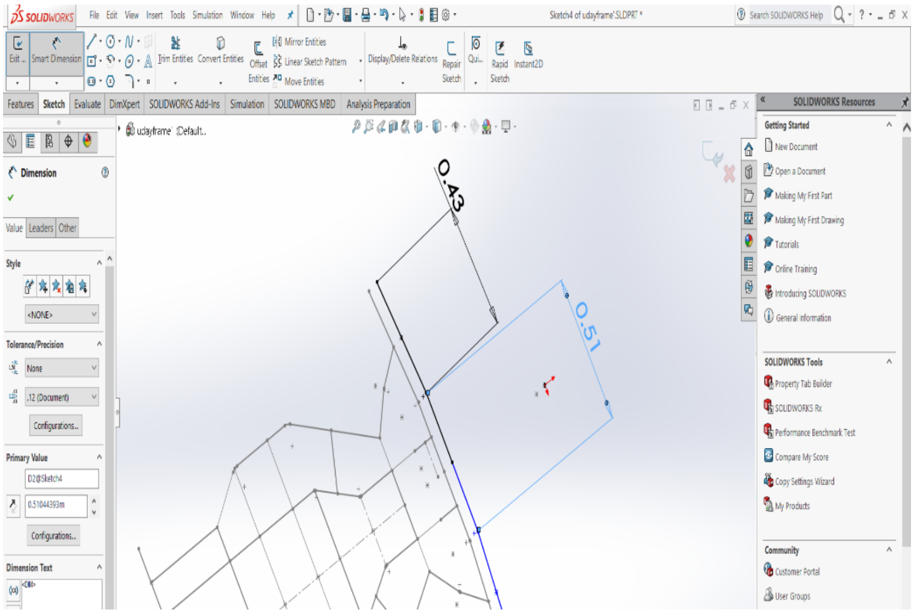

Fig 4.1(b) - Modelling of “The Crab Frame” (Dimension-II)

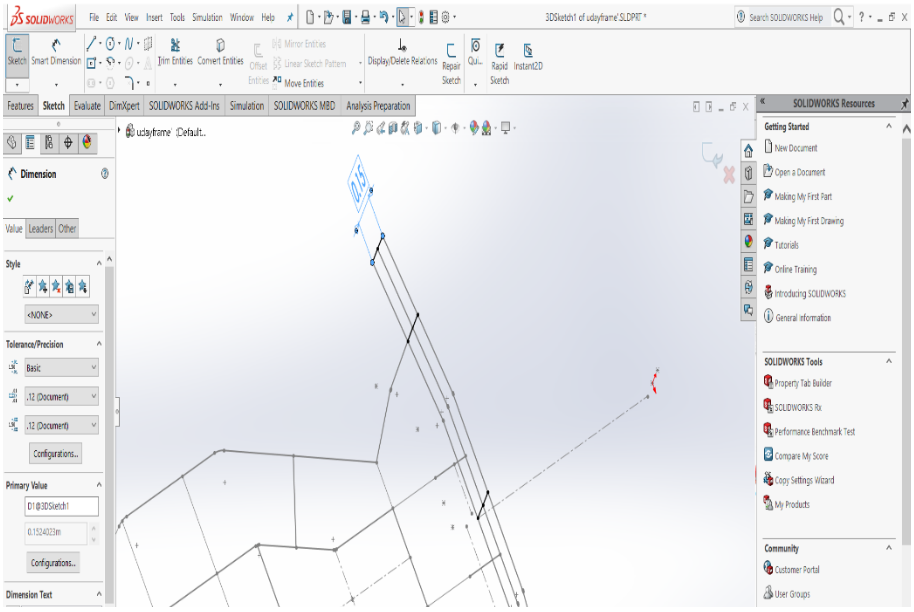

Fig 4.1(c)- Modelling of “The Crab Frame” (Dimension-III)

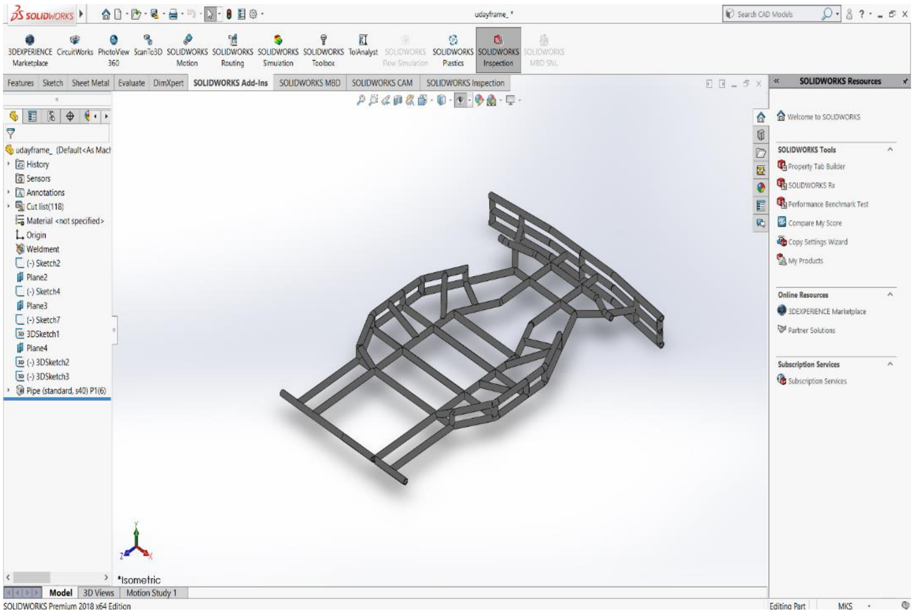

Fig 4.4- Final model of “The Crab Frame”

4.1.1 SIMULATION OF THE FRAME

Further, we simulated the front impact collision using Solid Works simulation tools. The results clearly show that the frame is really strong and can withstand high amount of loads without letting the deformation reach the driver’s body. But, we were missing the fact that, making the frame too rigid will leave the driver more prone to the impact loads. Ironically, we made a frame which was pretty strong but at the cost of driver’s safe.

For the simulation of the frame, the material chosen was *AISI 1020*. The material type is Linear, Elastic and Isotropic. After the material selection, mesh was created. In order to run this study, the rear part of the frame was fixed as the impact analysis of the front part of the kart was of utmost preference.

This is because, during any race, there are many chances of the kart ramming into another kart. This usually creates an impact on the bumper of the frame and hence causing a deformation. The process of simulation of the first frame is depicted pictorially.

The process of applying the material, creating the mesh and fixing the rear part of the frame are shown in Fig (4.1.1), Fig (4.1.2) and Fig (4.1.3) respectively.

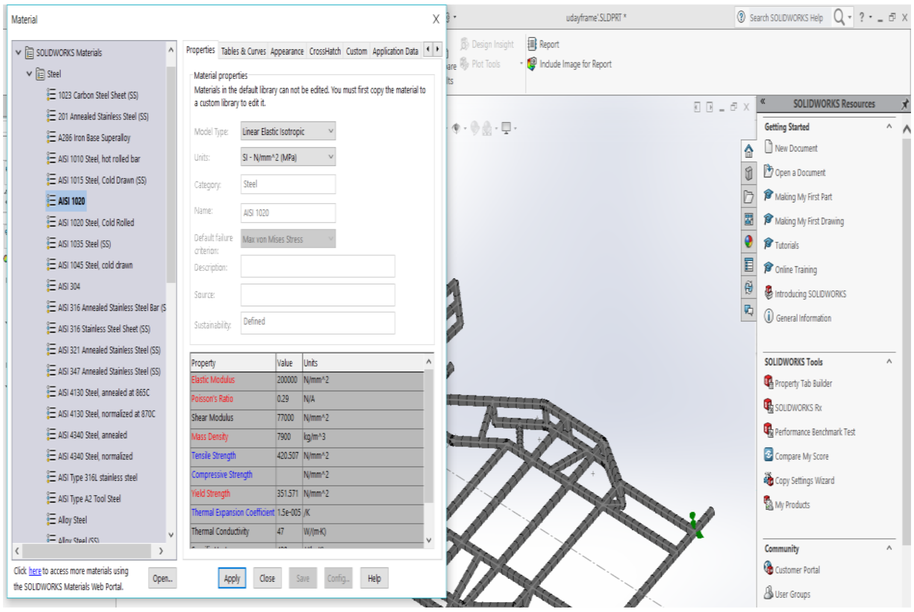

Fig 4.1.1- Applying the material (AISI 1020)

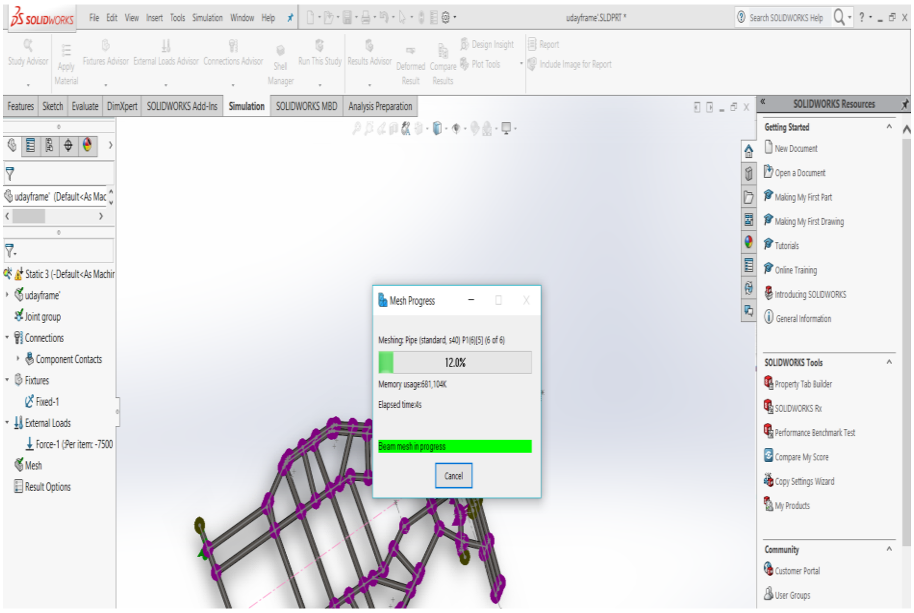

Fig 4.1.2 - Creating the mesh

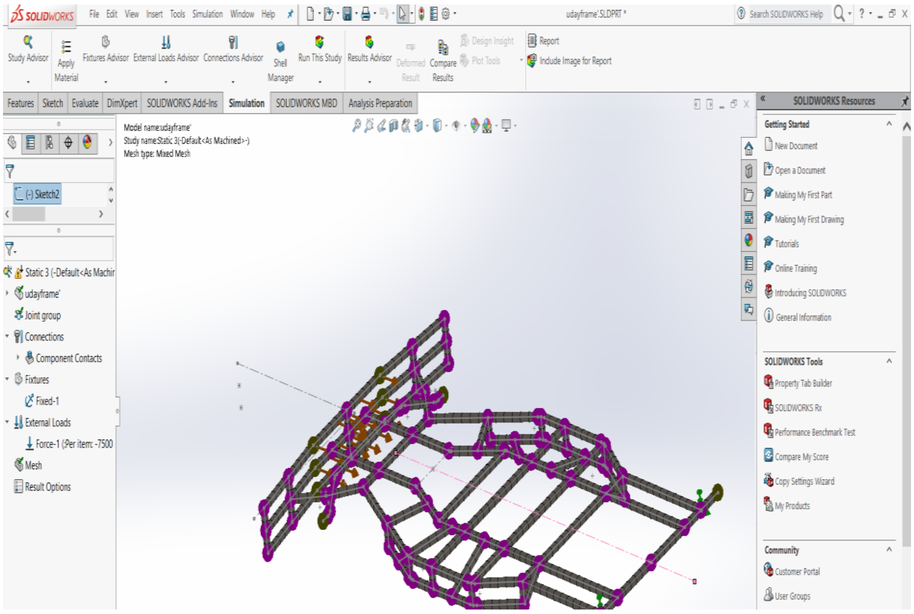

Fig 4.1.3- Fixing the rear part of the frame

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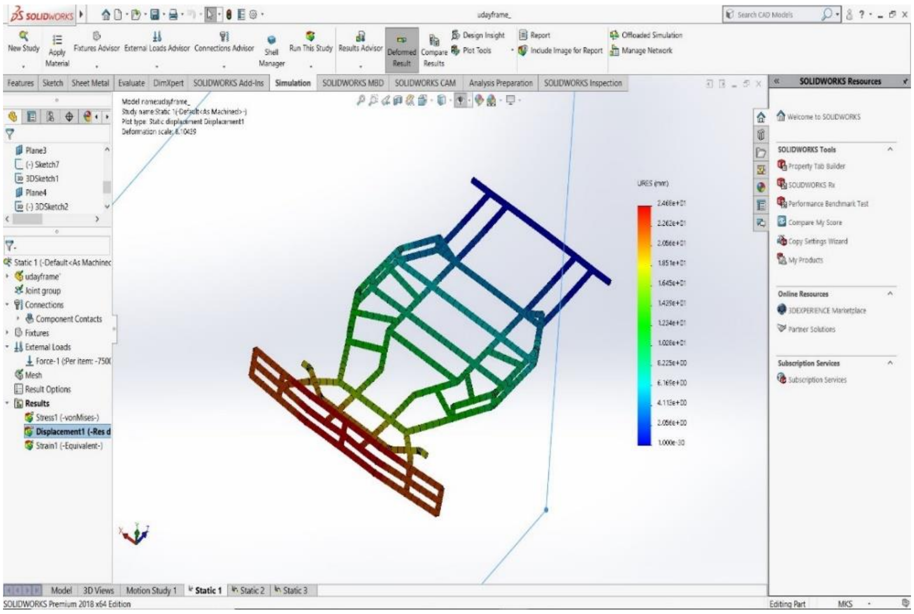

Fig 4.1.4- Impact Analysis of the Frame

The result after the simulation of the frame is shown in Fig (4.1.4). The red coloured part of the frame depicts the region with the maximum impact and the blue coloured part depicts the region with the least impact. From the figure, it can be concluded of the first frame that it experiences maximum impact at the front part i.e., of the frame.

4.1.2 DRAWBACKS OF THE FRAME

This frame had the following drawbacks:

1. A long protruded front which gives drivers a hard day at the track.
2. Heavy frame which reduces the performance of the kart drastically.
3. Highly rigid frame which makes the driver more susceptible to injuries during accidents.

For overcoming these disadvantages, we had to make a lot of changes in the frame design. These changes have been explains further.

4.2 DESIGN OF SECOND FRAME

As we can see, the previous frame is overwhelmingly rigid leaving the driver more vulnerable to impact loads. This is a similar case to that of an Ambassador car which is relatively unsafe for the passengers which is due to its overly rigid body. Also, the weight of the frame has been a serious concern. Now we started looking forward for a frame which is more optimised in its performance. This optimisation includes decreasing the weight as well as the impact load on the driver. Implementing a lot of changes to the existing frame, we came up with a more reliable frame.

During the process of optimisation, the alterations made to the frame include change in the design as well as the change in the dimensions. The model of the kart was made relatively simpler in contrast to the previous one. The length of the chassis was decreased. The design of the bumper was completely changed to enable it to absorb impact.

The length of the frame was taken as *70.76 inch*. The width of the frame as measured at the front and rear parts of the frame were taken as *35.53 inch* and *32 inch* respectively. Additional material was added at the side portion in order to help the frame withstand any impacts from the side. This part was extended up to a length of *7 inch*.

The bumper was again divided into three parts. These three parts include a centre part of *14 inch* and two end parts which were bent such that they form a curvature of radius *1 inch* at the joints. Also the height of the front part of the frame was decreased to *4 inch* which would result in decrease of the material used and hence the weight.

The dimensions of the second frame in different orientations are pictorially shown in Fig 4.2(a), Fig 4.2(b), Fig 4.2(c), Fig 4.2(d) and Fig 4.2(e). The final model of the second frame is shown in Fig 4.2(f).

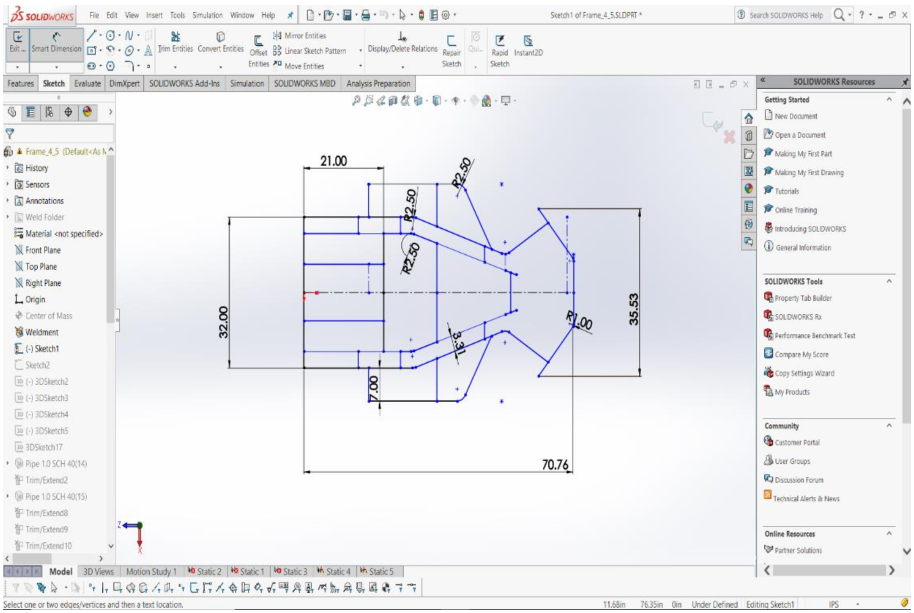

Fig 4.2(a) - Modelling of the second frame (Dimension-I)

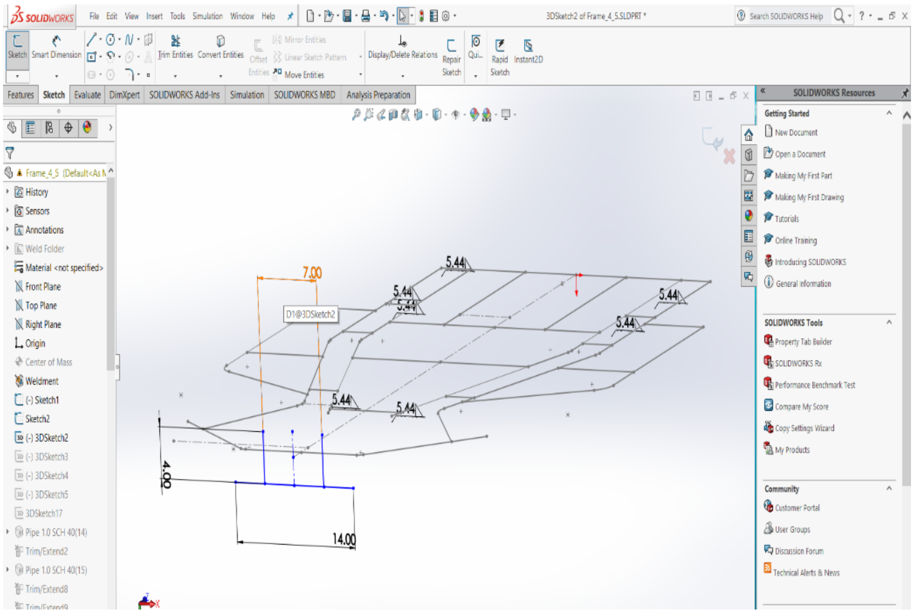

Fig 4.2(b) - Modelling of the second frame (Dimension-II)

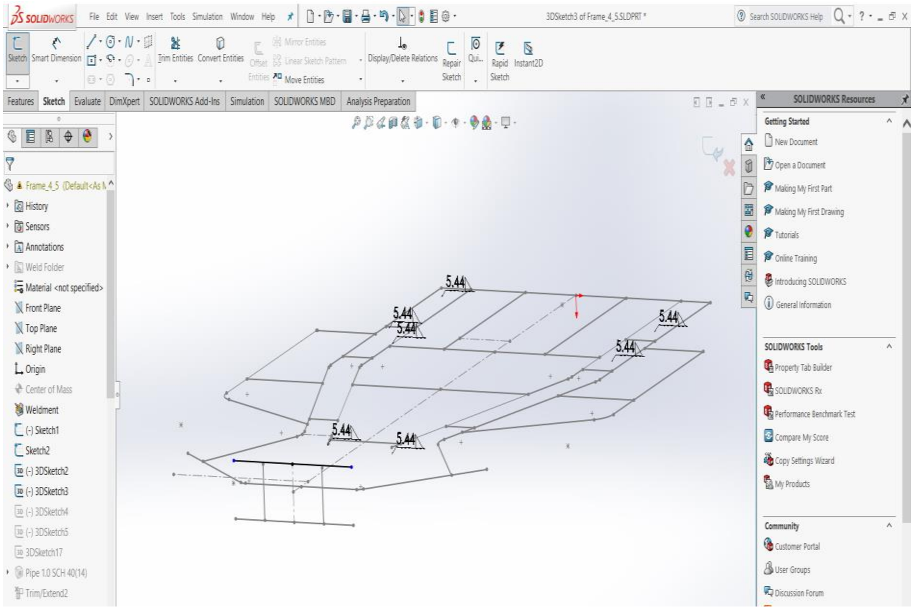

Fig 4.2(c) - Modelling of the second frame (Dimension-III)

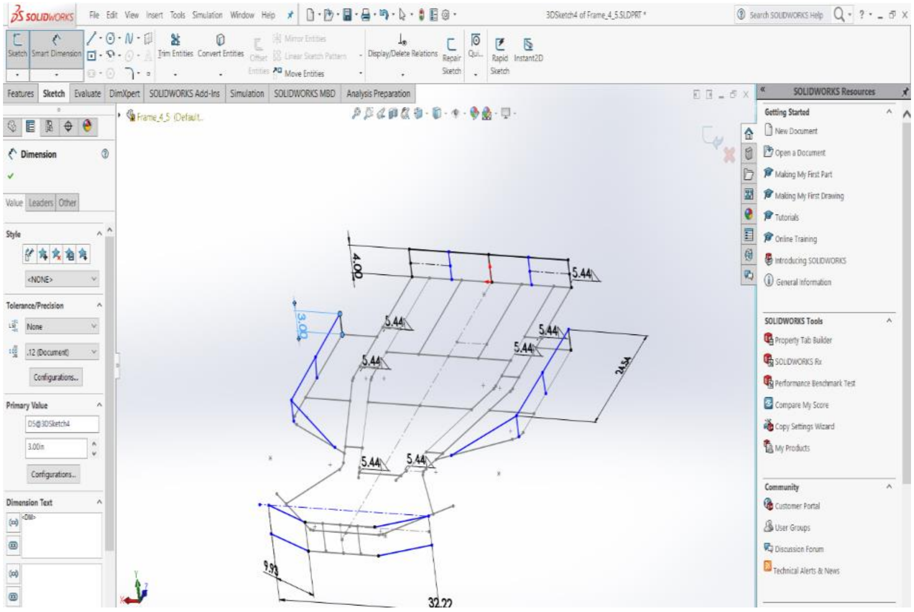

Fig 4.2(d) - Modelling of the second frame (Dimension-IV)

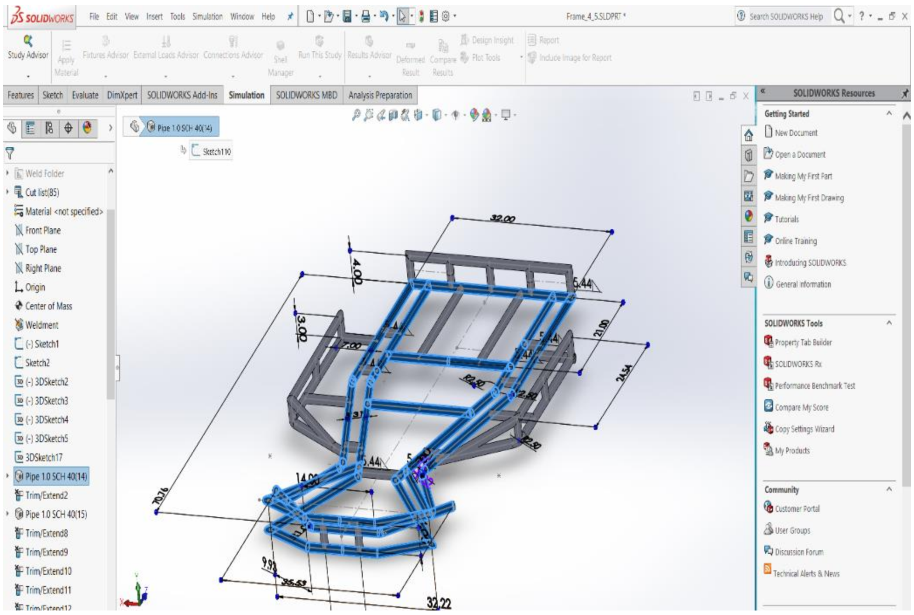

Fig 4.2(e) - Modelling of the second frame (Dimension-V)

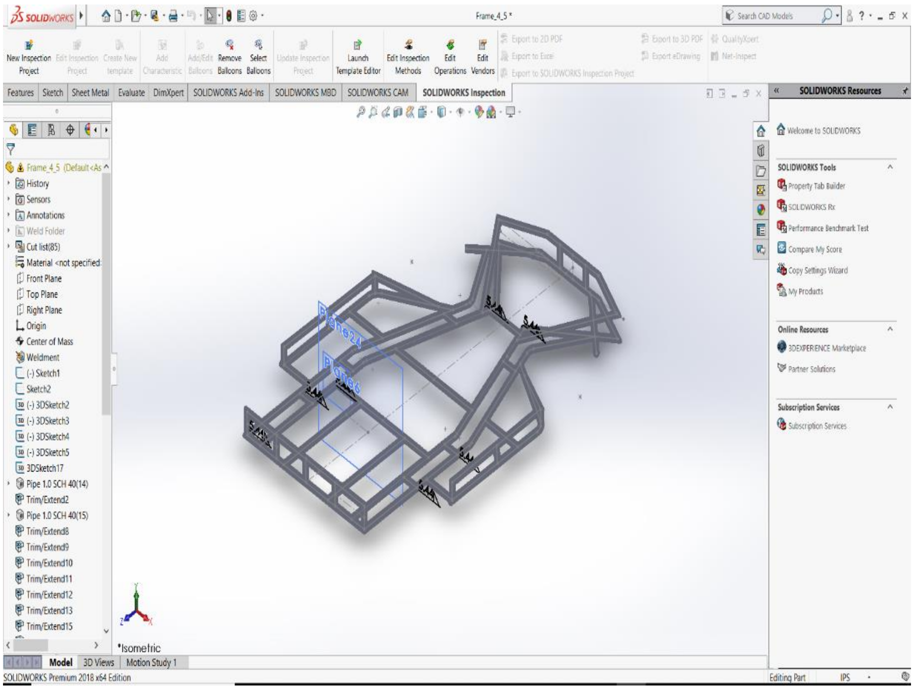

Fig 4.2(f) - Final Model of the Second Frame

4.2.1 SIMULATION OF THE SECOND FRAME

The preceding frame is provided with double railings on the sides and 3D projections for the bumpers on the front and side. The remaining frame is pretty much subtle and this decreased the frame weight drastically. Also, the rigidity of the frame has been reduced to a great extent. Now, for accurate results, the front impact simulation will be performed with the help of Solid Works simulation tools. The front impact simulation is performed and 'static displacement-displacement' plot is plotted.

For the simulation of the frame, the material chosen was *AISI 1020*, as it was done for the first frame. The material type is Linear, Elastic and Isotropic. After the material selection, mesh was created. In order to run this study, the rear part of the frame was fixed as the impact analysis of the front part of the kart was of utmost preference. This can be seen in Fig (4.2.1). The green coloured arrows represent the fixtures in the frame.

The direction of force that would act on the frame upon collision is taken towards the kart and the impact is shown on the centre part of the bumper. These processes are shown in Fig (4.2.2) and Fig (4.2.3).

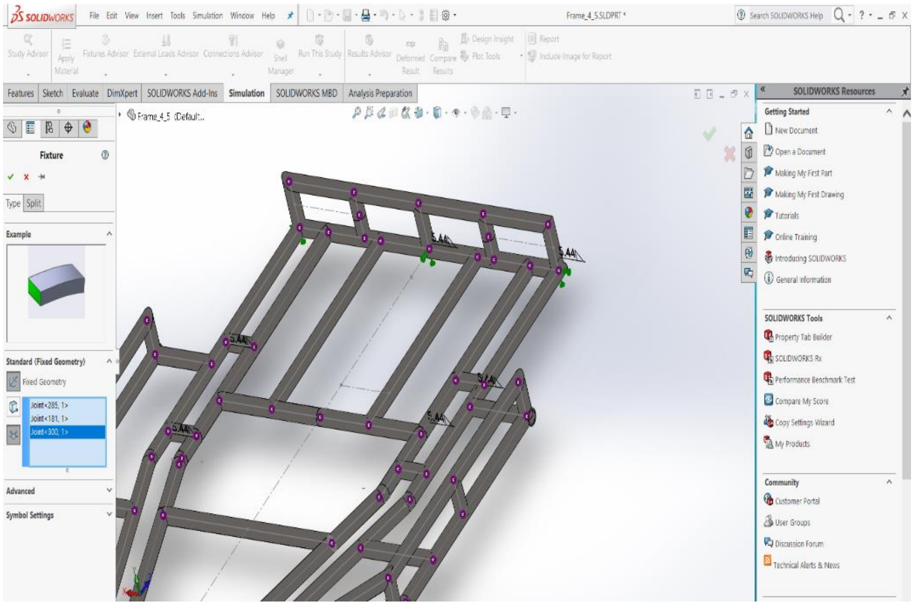

Fig 4.2.1 – Fixing the rear part of the frame

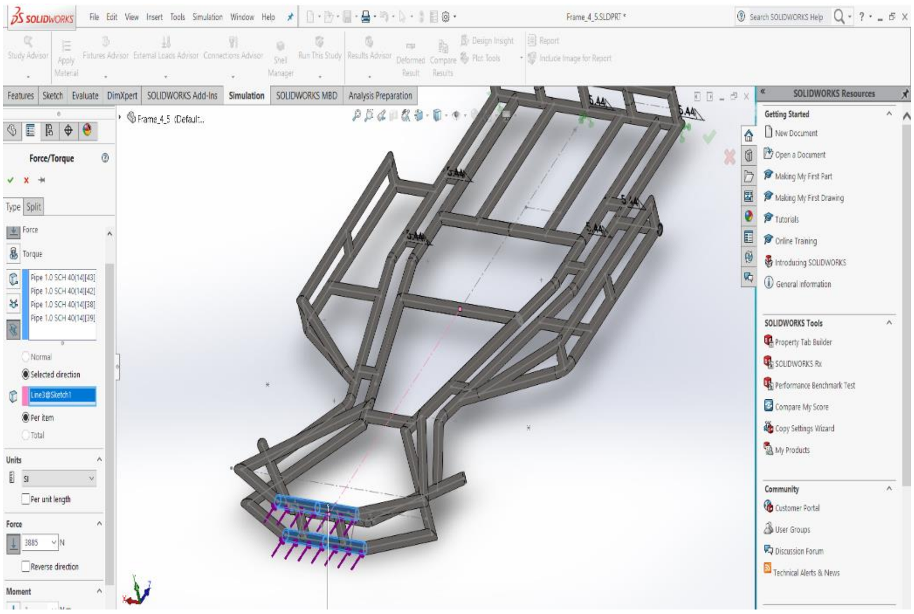

Fig 4.2.2 – Choosing the direction of applied Force

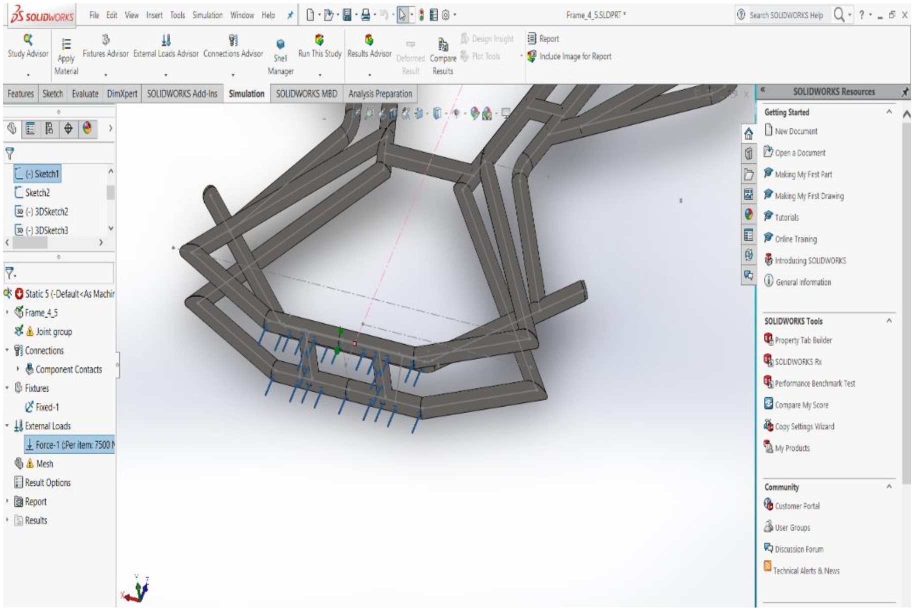

Fig 4.2.3 – Frame member prone to impact

The simulation process of the second frame is pictorially depicted. The process of applying the material to the frame, creating the mesh, mesh formed and the process of running the study are shown in Fig (4.2.4), Fig (4.2.5), Fig (4.2.6) and Fig (4.2.7) respectively. The final result i.e., the impact analysis is shown in Fig (4.2.8).

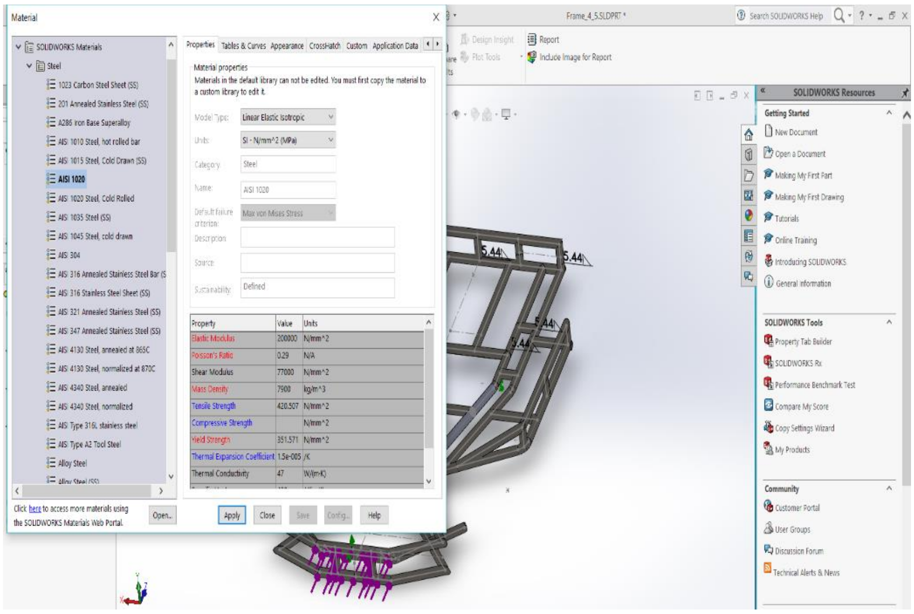

Fig 4.2.4 – Applying the material (AISI 1020)

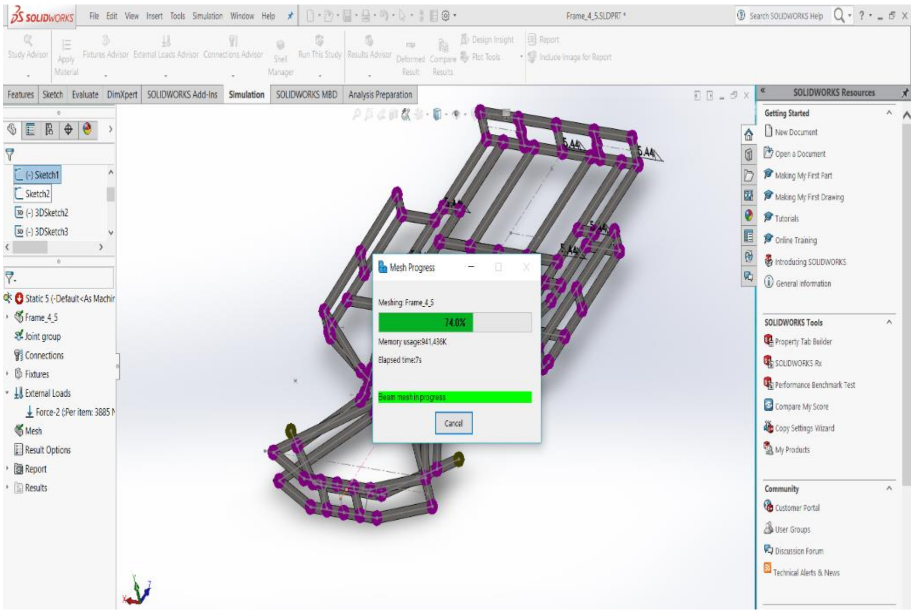

Fig 4.2.5 – Creating the mesh for the second frame

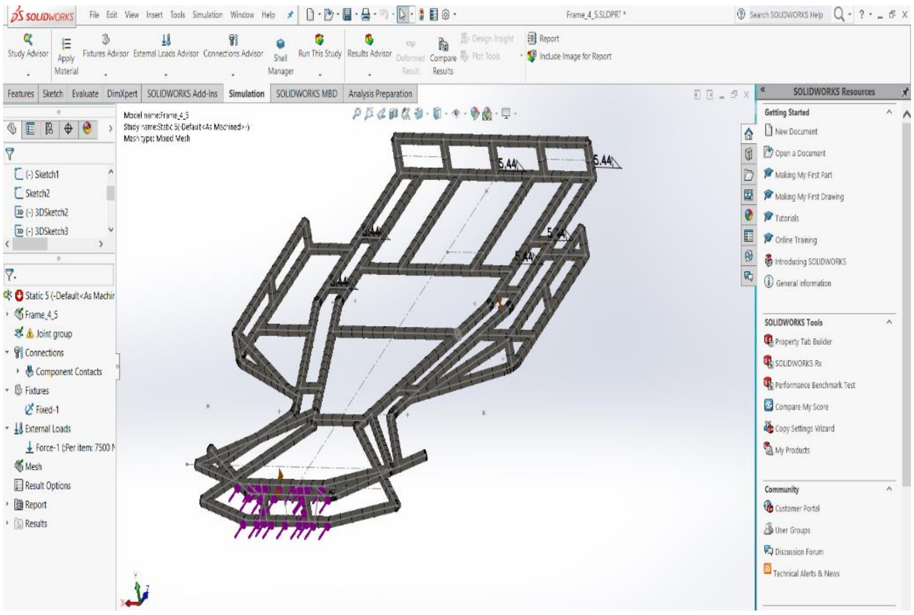

Fig 4.2.6 – Second frame after the mesh formation

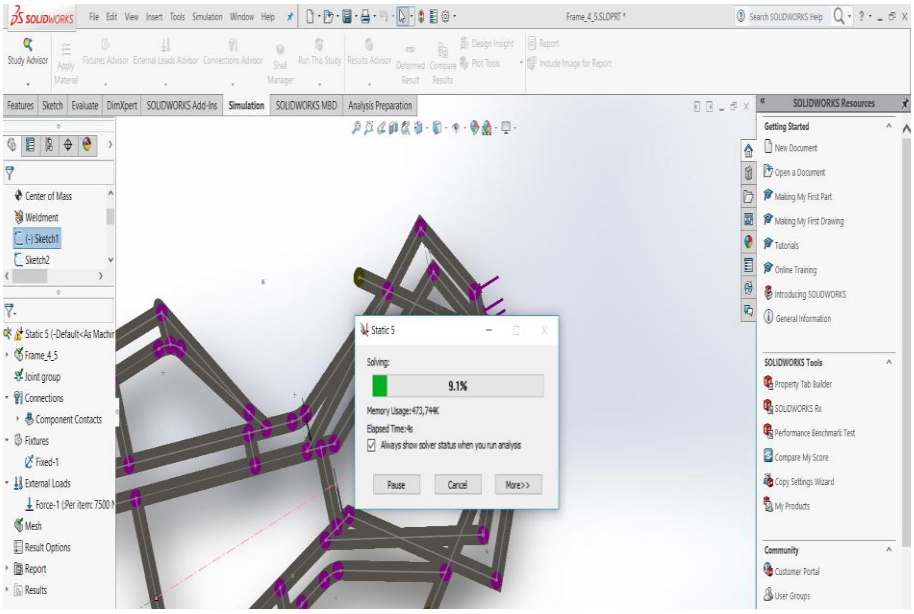

Fig 4.2.7 – Running the study of the second frame

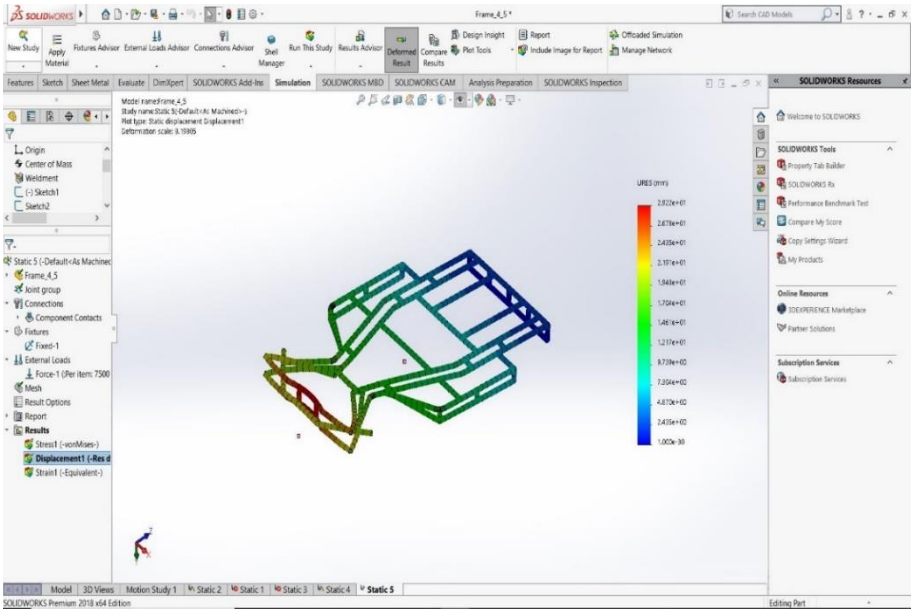

Fig 4.2.8 –Impact analysis of the Second Frame

4.2.2 DRAWBACKS OF SECOND FRAME

On analysing the results obtained from the plot, it is observed that a maximum displacement of 2.9cm occurs at the very front of the frame and this displacement doesn't reach the driver's feet. Hence, the frame can be considered safe for front impact collision. But, Von-mises stress plot clearly indicates that the stresses at the central parts of the frame are pretty low even at the worst case scenario. This leaves us thinking if we can reduce the weight of the body any further.

Usually, go-karts use low capacity engines (say 0.2lt engine) which produce less torque. These engines are usually not compatible with heavy chassis karts. So, it is always preferred to make the kart as light as possible to improve the vehicle performance. The majority of weight comes from the frame and hence, reducing the weight of the frame is a good bet for making the go-kart lighter. So, we further modified the frame by removing the secondary railing from the sides of the frame. Further, we performed various simulations on the modified frame and the results have been discussed in detail.

4.3 DESIGN OF THE FINAL FRAME

The analysis of previous frames gave us the motive to design a frame which is less in weight as well as, not compromising on driver's safety. Also, keeping in mind the safety aspects of driver, we wanted our frame to take up maximum load during collision and so we wanted to make it less rigid. Our solution thus was, removing material from places where stresses generated were low and adding a 3-Dimensional arrangement at the front to decrease displacement.

Based on these inputs, we have designed the final frame which is optimised to a maximum extent in all aspects. In comparison to the previous frame, very slight changes were made with respect to the design and dimensions of the frame. The length of the frame was increased whereas the width was decreased when measured at the bumper.

The length of the frame was taken as *73 inch.* The width of the frame as measured at the front and rear parts of the frame was taken as *26 inch* and *36 inch* respectively. The side part of the frame was extended up to a length of *6 inch* in either directions.

As done in the previous two frames, the bumper was again divided into three parts. These three parts include a centre part of *11.93 inch* and two end parts which were bent such that they form a curvature of radius *2.50 inch* at the joints. The height of the front part of the frame was kept the same i.e., *4 inch.*

When compared to the previous frames, this frame was found to have the least material density that would ultimately result in the decrease of weight during fabrication. It was also found to be the safest frame out of all the three designed frames.

The dimensions of the second frame in different orientations are pictorially shown in Fig 4.3(a), Fig 4.3(b), Fig 4.3(c). The model of the final frame is shown in Fig 4.3(d).

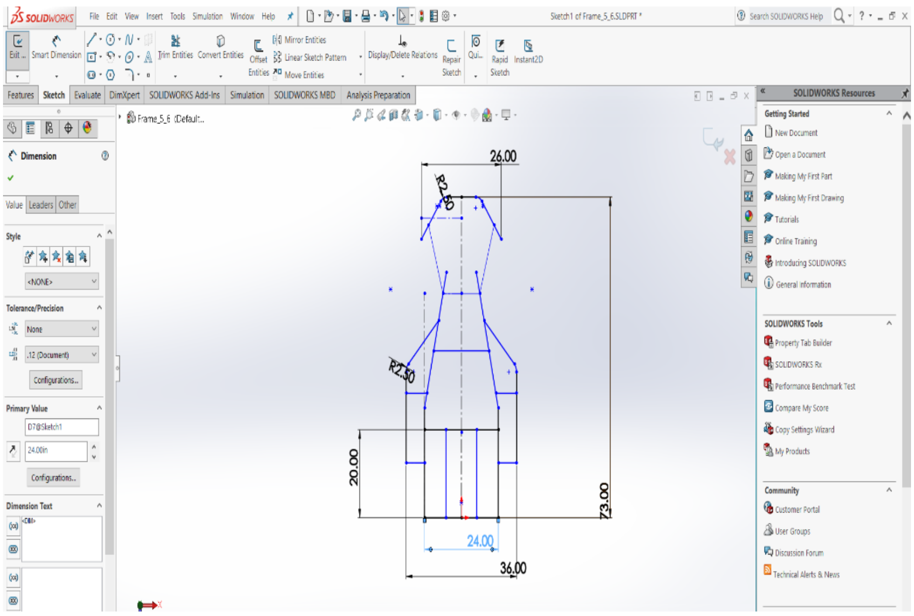

Fig 4.3(a) - Modelling of the final frame (Dimension-I)

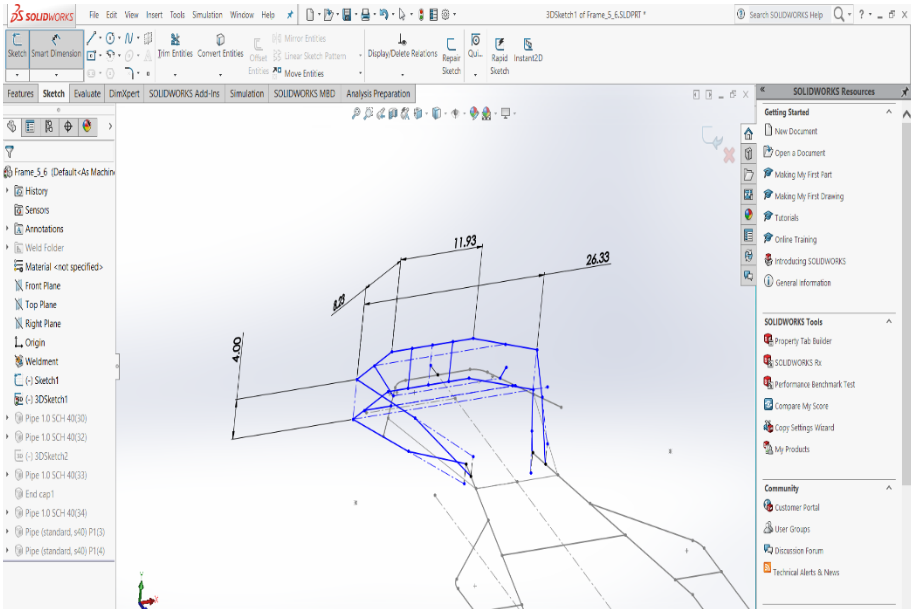

Fig 4.3(b) - Modelling of the final frame (Dimension-II)

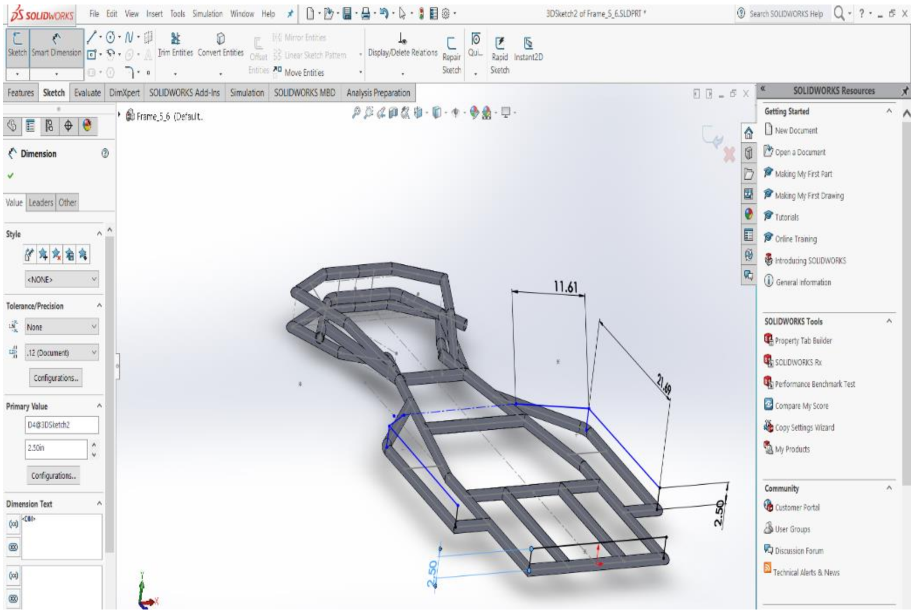

Fig 4.3(c) - Modelling of the final frame (Dimension-III)

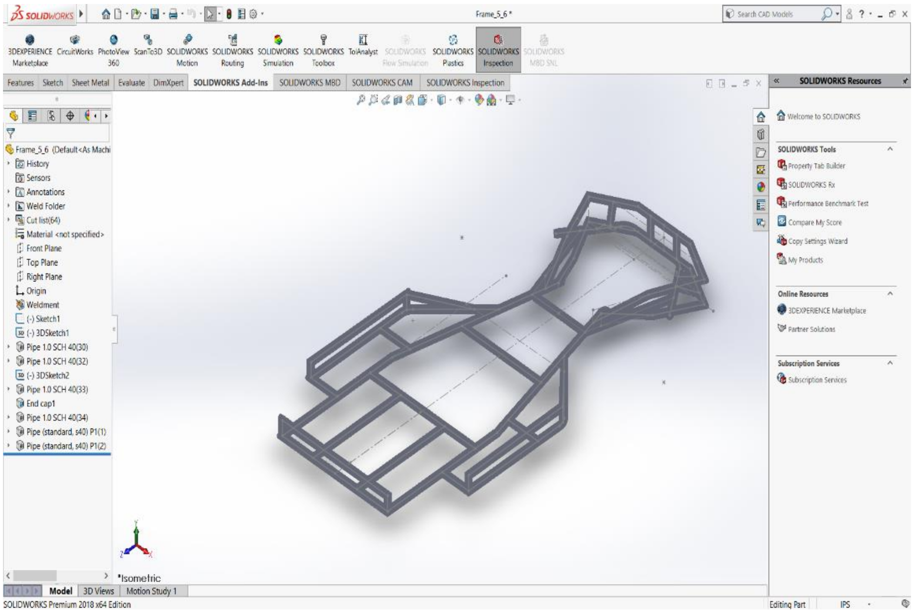

Fig 4.3(d) – Final model of the third frame

It is clear from the analysis of previous frames that the stresses generated at the centre of frame are considerably low and hence we experimented removing excess material from that part. Also, the analysis of previous frames have shown higher displacements at the front part. So, we improvised the frame by adding 3-Dimensional element to the front of the frame. We believed this could prevent the displacement of the frame from reaching the driver’s legs. Further, material was added to the side bumpers in the 3-Dimensional plane to absorb forces when collision occurs from sides.

As stated earlier, driver safety was our primary concern and so we wanted to test our frame to the highest limit. The worst case scenario while driving a go-kart would be a head on collision between 2 karts moving at their highest velocity (say 67kmph). So we considered this as our testing case and calculated the force developed during collision using engineering mechanics.

4.3.1 FRONT IMPACT ANALYSIS

General in the case of pure elastic collision in front impact the linear velocity remains 67kmph or 18.88 m/s according to our calculations. Hence the value of force is calculated by mass moment equation that is,

$$F=m*(v/ T)$$

Where, T is the duration of time.

Generally the collision takes place for a very short duration of time as T=0.68s and the gross weight of the vehicle is (m) = 125Kg (maximum including driver wt. = 68Kg, as suggested).

$$F=68 * [(18.88-0)/0.68)]$$

In the front impact the worst case is head on collision so after calculation the impact force came up to 4F= 7770N

4.3.2 SIDE IMPACT ANALYSIS

In the case of collision by side impact the value of the impact force generated is calculated in the same way as in front impact. The worst case for a side impact is our kart is in rest and the other kart has collided coming with maximum speed The side impact force is exactly half of the front impact i.e.,

$$F=3885N$$

Hence the calculated force were placed on one side of the model of frame while keeping another side fixed and the stresses were simulated.

4.3.3 SIMULATION OF THE FINAL FRAME

Further, we used this force for static analysis in solid works simulator. Loads were applied at the front of the frame and the rear part was fixed. The analysis was run and the displacements were calculated.

For the simulation of the frame, the material chosen was again *AISI 1020*, as it was done for the first and second frames. The material type is Linear, Elastic and Isotropic. After the material selection, mesh was created.

In order to run this study, the rear part of the frame was fixed as the impact analysis of the front part of the kart was of utmost preference. This can be seen in Fig (4.3.1). The green coloured arrows represent the fixtures in the frame.

The direction of force that would act on the frame upon collision is taken towards the kart and the impact is shown on the centre part of the bumper. This process is shown in Fig (4.3.2).

The simulation process of the final frame is pictorially depicted. The process of applying the material to the frame and mesh created are shown in Fig (4.3.3) and Fig (4.3.4) respectively. The final result i.e., the impact analysis is shown in Fig (4.3.5).

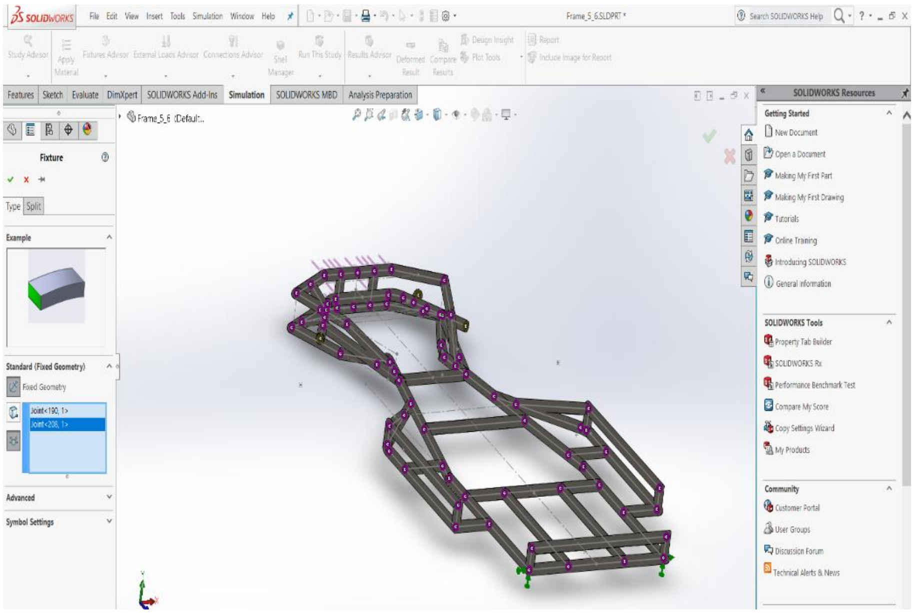

Fig 4.3.1 – Fixing the rear part of the frame

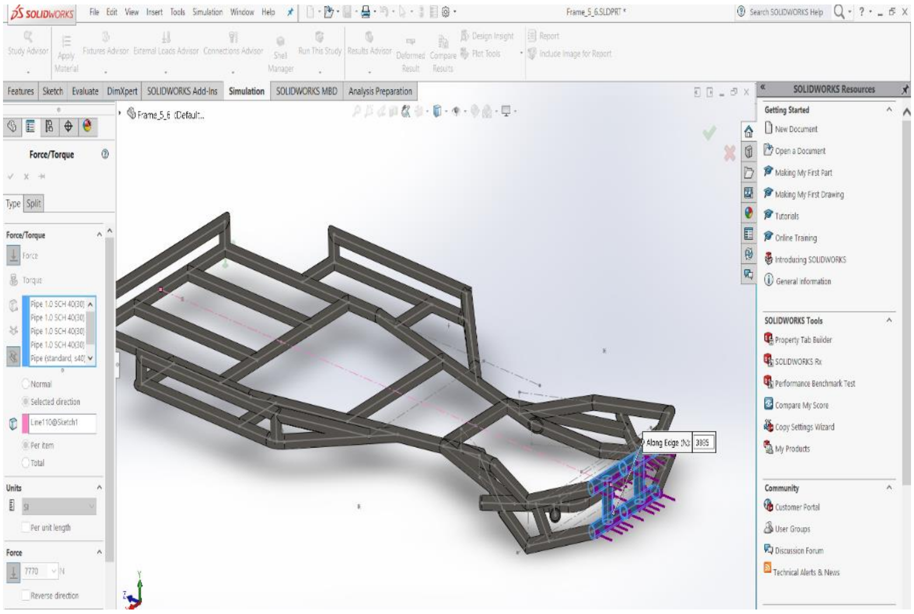

Fig 4.3.2 – Choosing the direction of applied Force

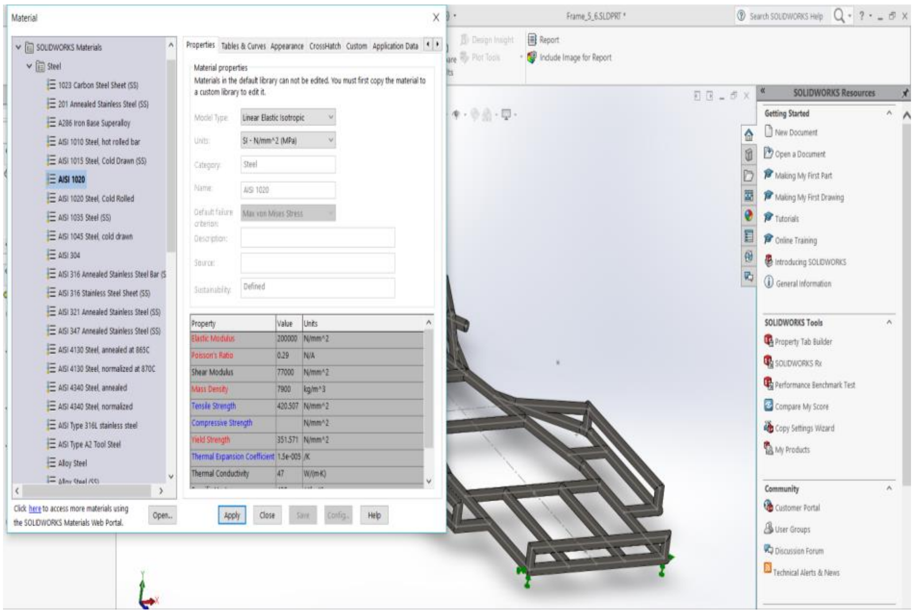

Fig 4.3.3 – Applying the material (AISI 1020)

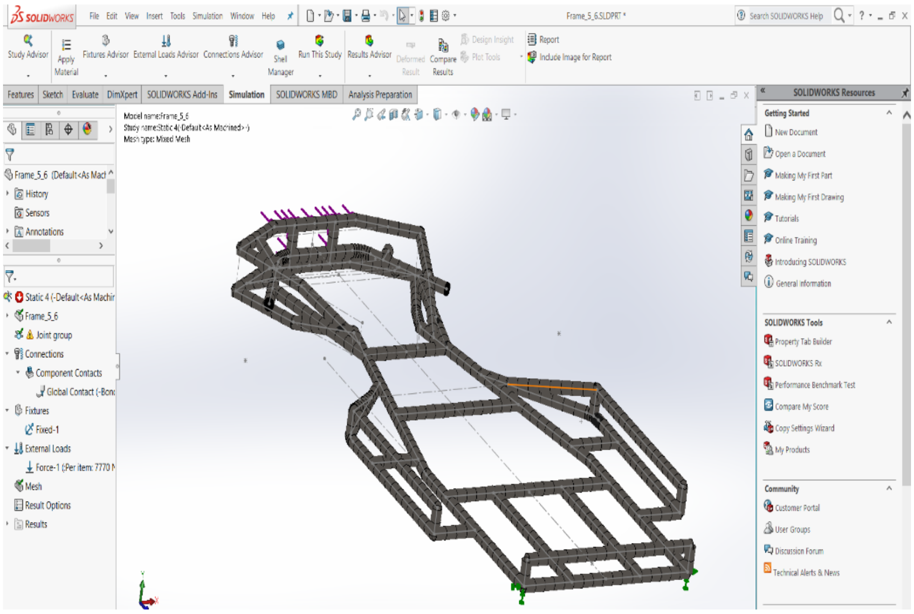

Fig 4.3.4 – Final frame after the mesh formation

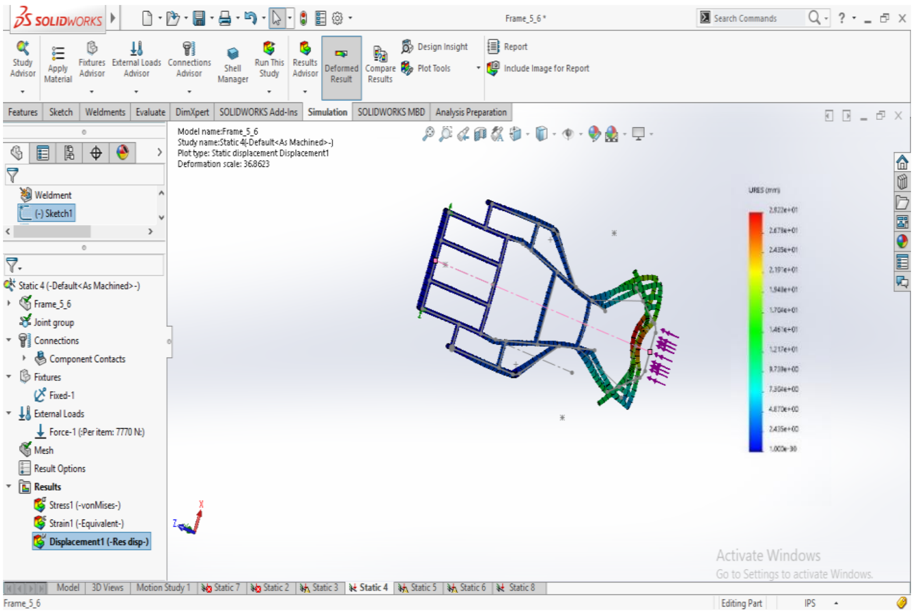

Fig 4.3.5- Impact analysis of the Final Frame

The results were clearly represented in the displacement-displacement plot. Maximum displacement is seen at the red shaded part. This maximum displacement is approximately *5.44mm* keeping the driver's legs uninjured. The displacement at other locations is relatively lower. Hence, we can conclude that the displacements observed even during a brutal collision are under limit and the driver's safety is highly improved.

Further, we need to check if there is any chance for failure in frame material. For this the stresses generated during collision are to be calculated. We obtain the stresses by plotting static nodal stress-stress plot in Solid Works simulator. The stresses generated are hence obtained. The static nodal stress-stress plot is as shown in the figure, Fig 4.3.6.

The plot clearly represents the Von-Mises stress generated in the frame. The maximum stress generated is way lower than the yield strength and hence the stress generated don't cause failure in the frame. The stresses generated in other locations is way lower than the maximum stress and hence there is no failure in the frame. Hence, the frame designed is completely safe even in the most demanding scenarios.

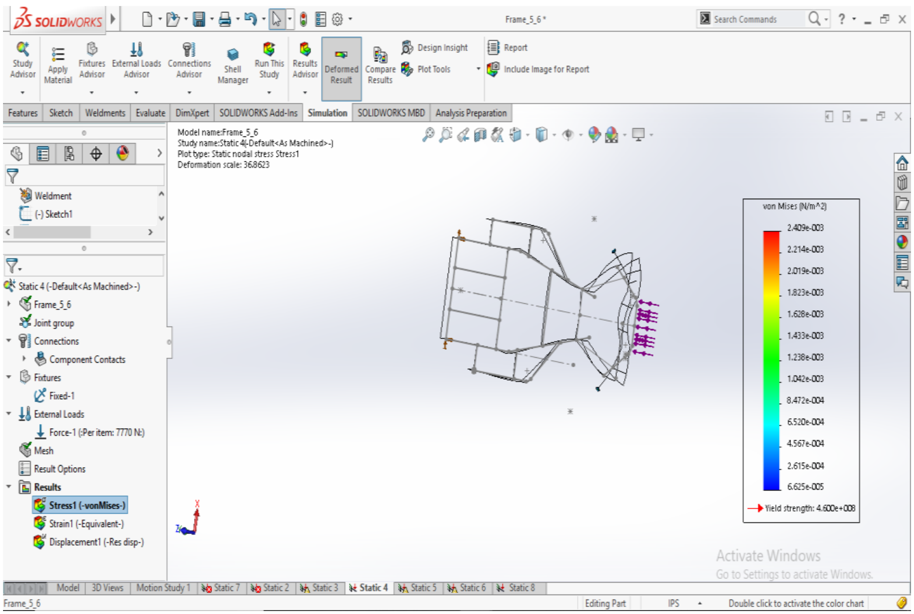

Fig 4.3.6 - Static Nodal Stress-Stress Plot of the Final Frame

Further, we perform torsional analysis on the frame to check the performance of frame while traveling on rough paths. The front of the frame are loaded in order to create a torsional effect and the rare part is fixed. It is as shown in the figure, Fig 4.3.7.

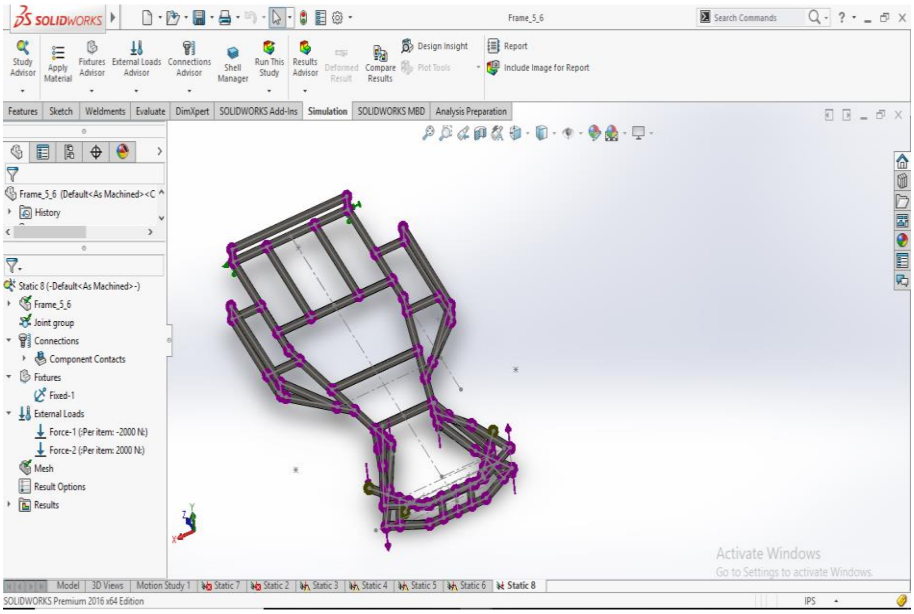

Fig 4.3.7- Torsional Analysis of the Final Frame

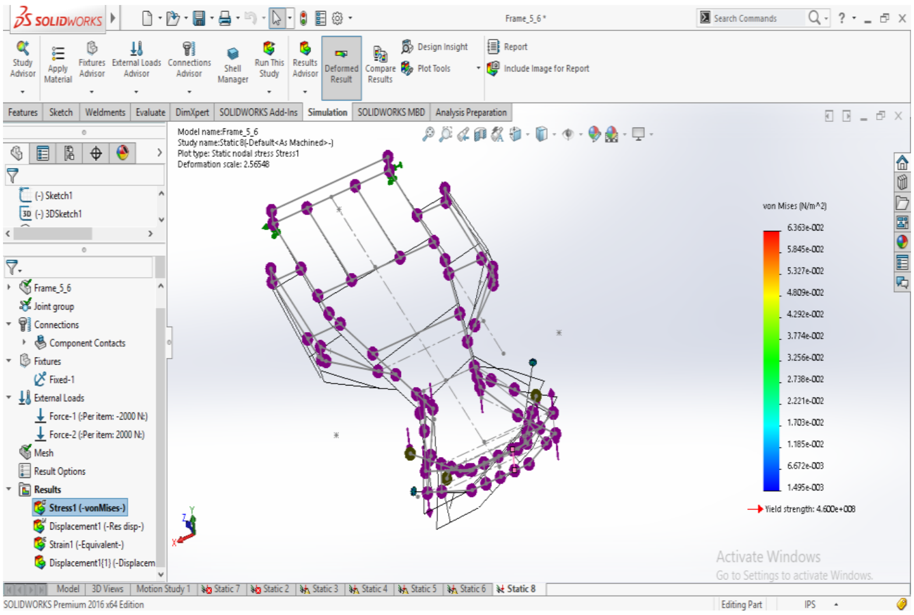

Fig 4.3.8- Stress-Stress plot of the Final Frame (Torsional)

Now, we run the analysis in Solid Works simulator to obtain displacement and von-mises stresses. First, we plot the static nodal stress-stress curve to obtain the Von-mises stresses. The stress-stress plot is as shown in the figure, Fig 4.3.8.

The maximum von-mises stress generated is 6.36*10^2 N/m^2. This way less than the yield stress and hence the material doesn’t undergo failure. The stresses in other locations is relatively lower than the maximum stress and hence the frame is safe even when torsional loads are applied. Further we need to look at the displacement produced in the frame during the torsional loading. For this we will have to plot a static displacement-displacement plot in Solid Works simulator. The static displacement-displacement plot is plotted and the displacement generated is obtained. The displacement plot is as shown in the figure, Fig 4.3.9. This frame is safe as far as the driver safety is concerned.

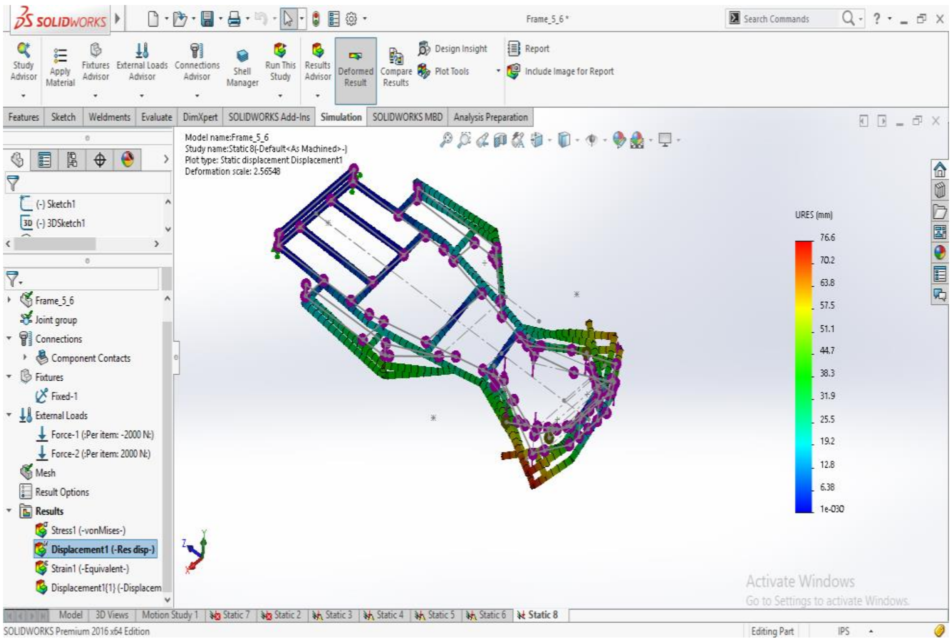

Fig 4.3.9- Static displacement-displacement plot of the Final Frame (Torsional)

CHAPTER-5

RESULTS

After following a rigorous procedure of design, simulation and redesign, we have come up with a frame which is safe, strong and light in weight. After taking into consideration ISI 1018, AISI 1020, AISI 1030 and AISI 1040 for the frame material and performing simulations and market survey for each metal, we have opted AISI 1020 as our final frame material. Though AISI 1030 and 1040 had higher strength and considerably lower weight, they were costly. Further, AISI 1018 couldn't provide satisfactory results in the simulations.

We made sure it doesn't get too rigid or too heavy by using the iterative procedure followed for design. Also, we made sure that our frame complements to achieve a square geometry after the tyre assembly is been done. This becomes important because, a square geometry can largely help us in reducing the drifting tendency of the kart and makes it more stable. The comparison of the extent of impact on the Frame I, Frame II, Frame III when the kart collided with an another one with its bumper is shown in Fig 5.1, Fig 5.2 and Fig 5.3 respectively.

Design Number	Frame I	Frame II	Frame III
Displacement of Front Part (in mm)	20.68	29.22	31.03

The percentage errors between Frame I – Frame II & Frame I – Frame III are as follow:

% error between Frame I – Frame II = [(29.22-20.68)/20.68]x100 = 41.29%

% error between Frame I – Frame III = [(31.03-20.68)/20.68]x100 = 50.04%

Since the values of the displacements have increased while changing the design, we got positive errors. This helps the frame in absorbing the impact and hence ensures the safety of the driver which is essential for karts during race.

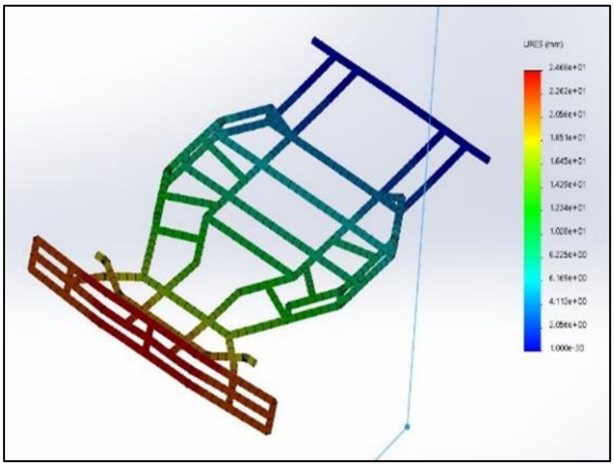

Fig 5.1 – Impact on Frame I

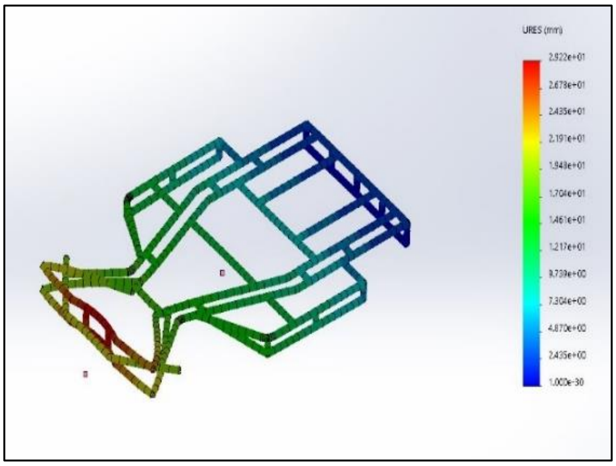

Fig 5.2 - Impact on Frame II

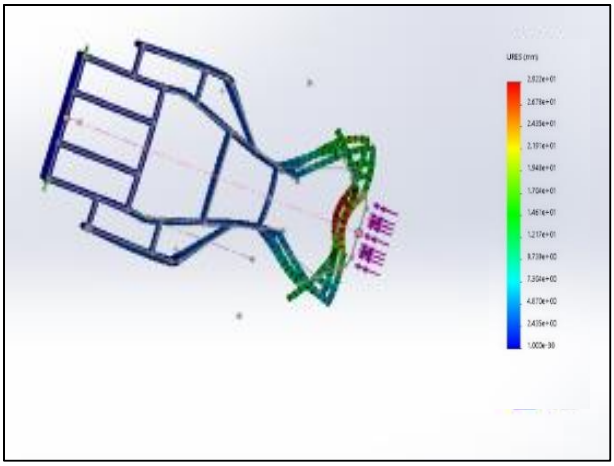

Fig 5.3 - Impact on Frame III

CHAPTER-6

CONCLUSIONS

Our concept is to build the chassis for go kart. Number of methods is adopted to design the chassis with all the stress factors. Not only sustainability of chassis, but it is also designed according to the components function like brake linkage, acceleration cable linkage etc.

There are several factors to be considered that are common to all engineering vehicles. With an approach of engineers can come up with the best possible product for the society. The chosen design is the safest & the most reliable car for any racing vehicle. All the parameters like Reliability, safety, Cost, Performance, aesthetics, ergonomics, Standard dimensions & material were also taken in consideration on the same time. Wherever possible finite element analysis was done on the regularly loaded parts & modifications were done accordingly to avoid any type of design failure.

The designed go-kart is able to withstand against any adverse condition on road as each component is designed specifically considering all types of failures and safety issues; it is the best vehicle for racing on circuit.as there is no suspension used in kart roll cage is designed in such a way that it having maximum flexibility in slight twisting motion to accommodate the role of suspension while turning and other twisting motions.

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(2) "*Design Report of a Go-kart vehicle*" by Shaik Himam Saheb, Govardhana Reddy, Md. Hameed, Department of Mechanical Engineering, Guru Nanak Institute of Technology, Hyderabad, India.

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