DESIGN, ANALYSIS AND MANUFACTURING OF GO-KART CHASSIS

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ABSTRACT
This report aims to model, simulate, perform the static and dynamic analysis and fabrication of a go kart chassis consisting of Circular beams. Modelling, simulations are performed using modelling software i.e. PTC CREO 2.0 and analysis on ANSYS V14.5. The maximum deflection is determined by performing dynamic analysis.

The chassis is designed such that it requires less material and as well as it is strong enough to withstand the various impacts on it. Strength and light weight were our basic consideration throughout the design of the chassis of the kart. Hence, AISI1018 was selected as an appropriate material for design which is a medium carbon steel with properties such as light weight, high tensile strength, high machinability, better weldability, etc.

All the impacts and stresses were analysed by considering the severe working conditions and then the design was analysed in the analysis software. Step by step modifications in design were made as found necessary and as analysed on the software. After the complete analysis and the approval of design by inspecting it in all the modes of failure the design was finalized and was selected to fabricate which will not fail in any extreme criteria of stresses or load induced.

KEYWORDS: chassis, material properties, total deformation, equivalent stress, machinability, weldability

1. INTRODUCTION

The automotive chassis is tasked with holding all the components together while driving, and transferring vertical and lateral loads, caused by accelerations, on the chassis through the wheels. Most engineering students will have an understanding of forces and torques long before they read this. Some people stress full with 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. The design section of the book will talk more about these items.

We designed a CAD model of the chassis on the 3D modelling software. Using this design software allowed the team to visualize the design in 3-D space and reduce errors in fabrication. The main criterion in chassis design was to achieve 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 required dimensions were roughly set using a virtual template to achieve the necessary clearances in case of a rollover situation. After a series of design changes and subsequent calculations, the final chassis design was decided upon. The design process of the vehicle is iterative and is based on various engineering and reverse engineering processes depending upon the availability, cost and other such factors.

So the design focuses on following objectives:

1. Safety
    - Serviceability
    - Strength
2. Ruggedness
    - Standardization
    - Cost
    - Driving Feel and Ergonomics, Aesthetics

- Durability

3. Light Weight
4. High Performance

2. CHASSIS DESIGN APPROACH

The chassis has been designed by taking factors like dimensional limits (wheel base, track width and height) operational restrictions, regulatory issues, constructional restrictions, regulatory issues, contractual requirements, financial constraints and human ergonomic as priority.

A basic chassis frame of circular pipes of diameter 1 inch and 2 mm thickness was designed and selected by taking the points of strength, availability and cost into consideration.

Research → **Design** → **Analysis** → **Manufacturing**

3.RESEARCH

By, research we made decision regarding type of material to use and type of cross section to be used.By research it was clear that circular cross section is best suitable for the chassis. Circular pipes are easy to manufacture therefore it was easily available in market in form of pipes for respective AISI 1018. It can be easily bent and uniform flow can be achieved. Circular cross section is also suitable for low load application. No stress concentration as there are no corners and edges and also torsional rigidity is high.

Tubing is available in standard fractional sizes to the 1/8th of an inch: 1, 1.12, 1.25 and 1.5. The wall thickness is limited to the common Birmingham tubing gauges. In this case these are: 1.5, 1.8, 2, 2.5 and 3mm.

The most commonly used materials are:

Table 1 Materials and Properties

Materials	Yield Strength (MPa)	Density	Cost per m in ₹
AISI 1026	260-440	17-27%	345
AISI 4130	435-979	18-28%	735
AISI 1020	230-370	18-28%	315
AISI 1018	270-400	18-29%	300

It is observed that material which has high machinability and weldability with less density in minimum cost is AISI 1018, also strength to weight ratio is higher for AISI 1018. AISI 1018 is a popular steel in race car industry.

AISI 1018 is low alloy steel containing chromium and molybdenum as strengthening agents. We choose it due to the good strength, toughness, weldability and also machinability. In case of low temperature forging, the non-uniform structure in certain areas of forged areas.

Table 2 AISI 1018 Chemical Composition

Elements	Content (%)
Fe (Iron)	97.03-98.22
Cr (Chromium)	0.8-1.1
Mn (Manganese)	0.4-0.6
C (Carbon)	0.28-0.33
Si (Silicon)	0.15-0.3
Mo (Molybdenum)	0.15-0.25
S (Sulphur)	0.04
P (Phosphorous)	0.035

Physical Properties of AISI 1018

Table no. 3 Physical Properties of AISI 1018

Properties	Value (Metric)
Density	7.85 g/cc
Yield Tensile Strength	360 MPa
Elongation at break (in 50 mm)	21.50%
Poisons Ratio	0.27-0.3
Modulus of Elasticity	190-210 GPa

4. DESIGN

4.1 Objectives

The frame is designed to meet the technical requirements. The objective of the chassis is to encapsulate all components of the kart, including a driver, efficiently and safely. Principle aspects of the chassis is focused on the design and implementation including driver safety, drive train integration, and structural weight and operator ergonomic. The most important priority in the chassis design was driver safety. The main component of the frame is divided into two major parts; first the front block (cockpit) for steering and seat position etc. and second rear block (engine compartment) for transmission and brake assembly. Both the blocks are separated by the firewall.

4.2 Definition of Basic Layout

It was important to define the wheel base, track width and height of the overall vehicle in order to proceed with the design. Considering above parameters, we formed the basic rectangular periphery. Considering this rectangular periphery, primary member layout was decided by sketching (by iteration). Considering the placement and the mounting of the sub systems the secondary members position is decided.

The position of the members was sketched and final rough layout of primary as well as secondary members were fixed.

4.3 Weight Distribution

For better stability and handling of the Kart, the best suitable weight distribution longitudinally was decided to be 50% on the left and right and along the lateral axis it was 45% on the front and 55% on the rear side of the Kart.

The reason for the major weight on the rear side was the better traction and good handling of the Kart, as the major load was on the rear side of the Kart due to the engine and driver.

The weight distribution majorly depends on the placement of the sub systems mainly engine and driver seat (Driver's weight) on the Kart chassis. The frame weight was considered at the center of the frame as it is symmetric about longitudinal axis. Also the sub systems were scattered hence the miscellaneous weight was at center. The miscellaneous weight consists of braking system, steering system, powertrain, axle etc.

Hence, for accurate placement the position was fixed with the help of calculation with the help of moment of inertia.

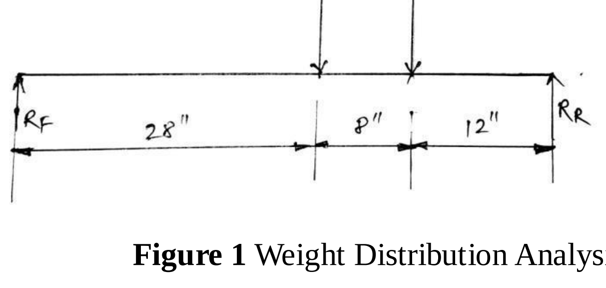

Figure 1 Weight Distribution Analysis

Wheelbase = 48”

Front track width =40”
Rear track width =42”

Driver weight = 588.6 N
Engine weight=313

Rf + Rr = (60*9.81)+(32*9.81) = 932 N..............................(1)
Taking moment about front axle, 60*25.4*28 + 32*25.4*36 = Rr*48 Rr =512.6 N

Therefore, from equation (1)
RF =419.4N

Weight distribution on front axle = 512.6/932 = 45%

Weight distribution on rear axle = 419.4/932 = 55%

But, the total weight of kart is assumed to be 180 kg with driver onboard. Assuming equal weight distribution of other sub systems,

Load on front axle = 45/100*1765.8=794.61N Load on rear axle = 55/100*1765.8=971.20N

4.4 Floor Planning

With the help of the performed calculations the secondary members were added or re positioned as per requirement.

After the successful allotment of the members, the whole chassis was drawn on floor as per the scale (without reduction). The floor plan helped us for visual analysing of the actual size of the chassis and placement of the sub systems. The problem faced in prototyping was we were unable to visualize the side view of the chassis hence this was overcome in the prototyping.

4.5 Computer Aided Design (CAD)

Computer aided design (CAD) is the use of computer systems to assist in the creation, modification, analysis or optimization of a design

CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation and to create a database for manufacturing. CAD is an important industrial art extensively used in many applications including automotive and aerospace.

We used a 3-D Modelling software, PTC CREO 3.0 for modelling of chassis of go-kart to keep the process simple. We used draw and sweep operation in the CREO in to complete the design. To denote the fabrication sites we used a draw, sweep and remove material while it is important in CATIA and SOLIDWORKS to use weld design module and weldments.

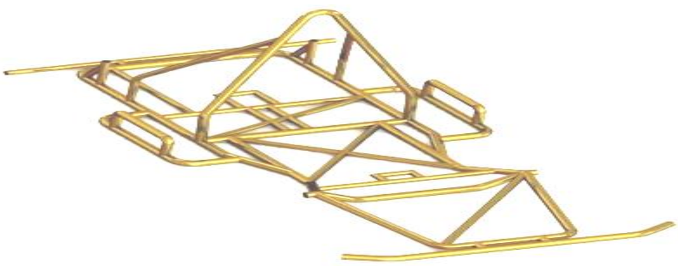

Figure 2 Design of Chassis

5. ANALYSIS

Structural integrity of the frame is verified by comparing the analysis result with the standard values of the material. Analysis was conducted by use of finite element analysis FEA on ANSYS software. To conduct finite element analysis of the chassis an existing 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, and rear impact. The test results showed that the deflection was within the permitted limit

5.1 Meshing

Auto meshing has been done in ANSYS 14.5 software. The element size was kept to 4mm to achieve enough no. of nodes and elements. Following data has been found after meshing of chassis.

Table no. 4 Physical Properties of AISI 1018

Properties	Numbers
No. of Nodes	866517
No. of Elements	435289

5.2 Boundary Condition

For all the impacts, the load was applied on the respective side of the kart chassis and the one element of the chassis was given the displacement in the direction of the applied force and the other element was kept fixed which resulted in more conservative approach to analysis.

The following conditions for the analysis is mentioned in the below:

a) Front Impact:

The steering knuckle was given displacement in the direction of applied force and rear bearing housing was kept fixed.

b) Side Impact:

The side from which the force was applied, respective steering knuckle and rear bearing housing was provided displacement in the direction of force applied and the opposite side steering knuckle and rear bearing housing was constrained completely.

c) Rear impact

The rear bearing housing was given displacement in the direction of applied force and steering knuckle was kept fixed.

5.3 Solving the Model

To ensure driver safety, required chassis strength, following dynamic impact scenarios as stated below were analysed using software to ensure the frame design will not fail.

a) Front impact analysis

Front impact was calculated for an optimum speed of 45 km/h. The loads were applied only at front end of the chassis because application of forces at one end. Time of impact considered is 0.2 seconds as per industrial standards.

$A=(u-v)/t$

$= (12.5-0)/0.2= 62.5$ m/s2

$F \times t = m \times (Vi-Vf)$

$F \times 0.2 = 200 \times (11.12 -0)$ F=11.2 KN

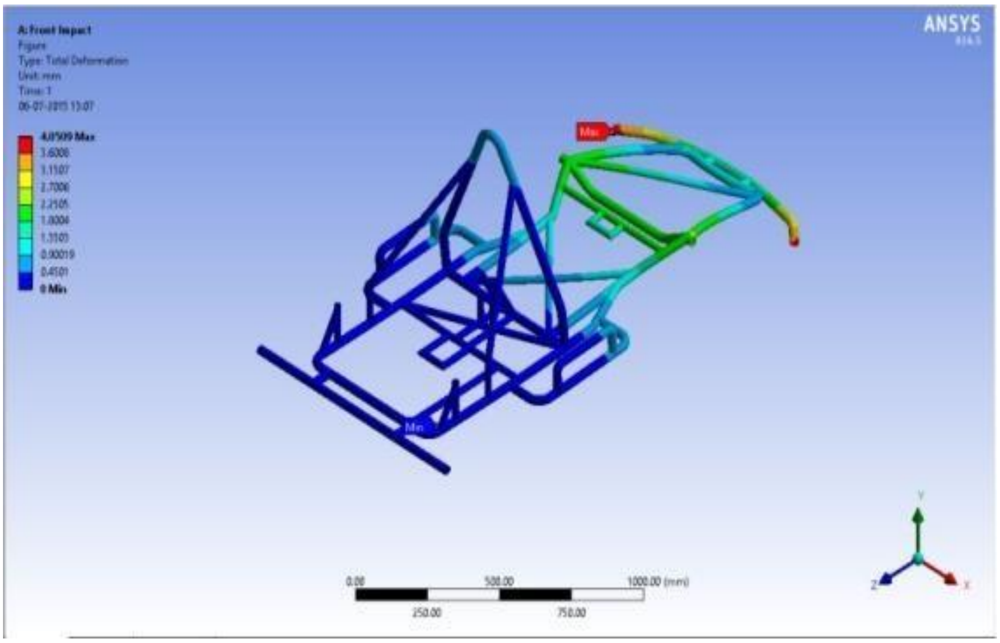

Figure 3 *Total Deformation*

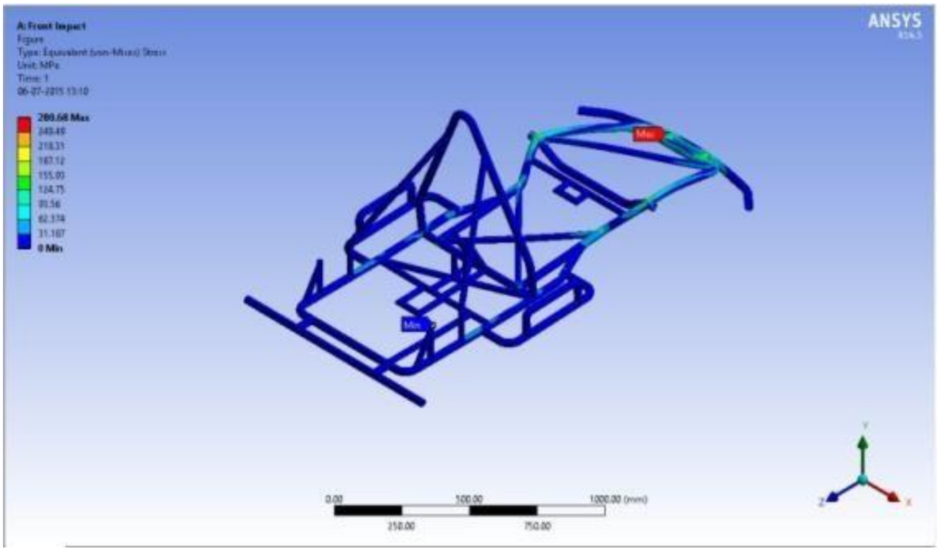

Figure 4 *Equivalent Stress*

Maximum Stress= 280.68 MPa

Now, Factor of Safety= Syt/Smax = 360/280.68 = 1.29

b) Rear impact analysis

Rear impact was calculated for an optimum speed of 45 km/h. The loads were applied only at rear end of the chassis because application of forces at one end. Time of impact considered is 0.2 seconds as per industrial standards.

A=(u-v)/t =(12.5-0)/0.2 = 62.5 m/s^2

F x t = m x (Vi-Vf)

F x 0.2 = 200 x (11.12 -0) F=11.2 KN

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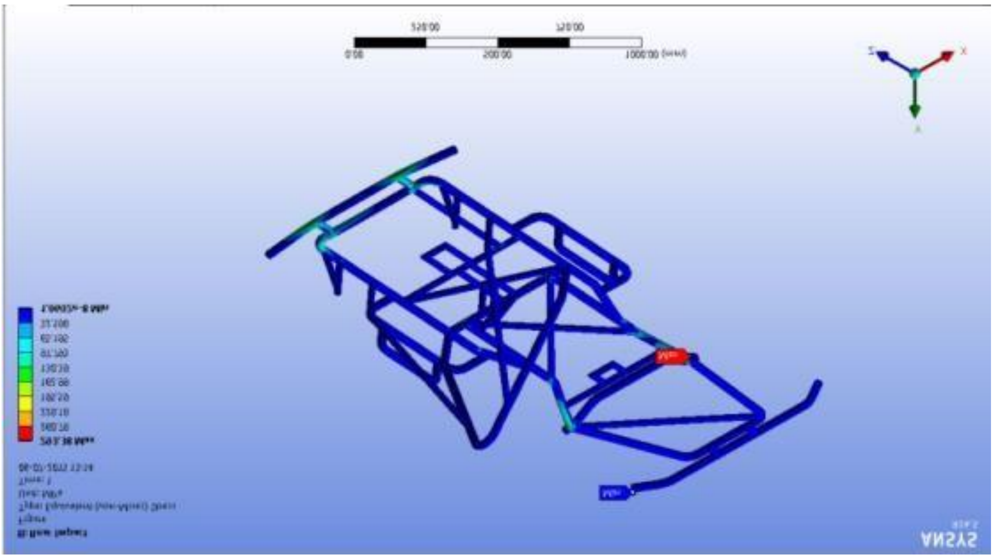

Figure 5 *Total Deformation*

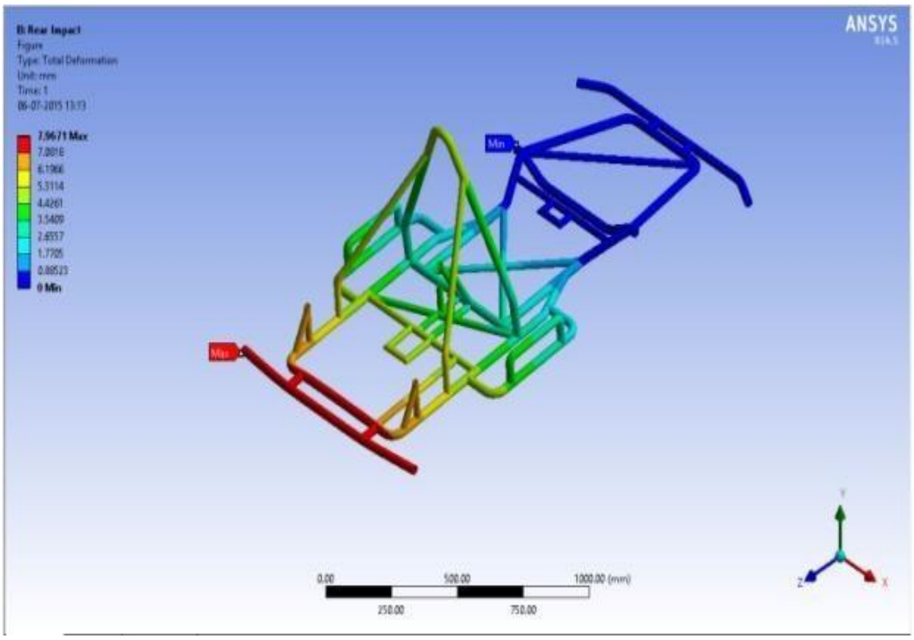

Figure 6 *Equivalent Stress*

Maximum Stress= 293.38 MPa

Now, Factor of Safety= Syt/Smax =360 /293.38 = 1.26

c) Side impact analysis

Front impact was calculated for an optimum speed of 45 km/h. The loads were applied only at front end of the chassis because application of forces at one end. Time of impact considered is 0.2 seconds as per industrial standards.

$A=(u-v)/t = (12.5-0)/0.2 = 62.5\ m/s^2$

$F \times t = m \times (Vi-Vf)$

$F \times 0.2 = 200 \times (11.12 -0)$

$F=11.2\ KN$

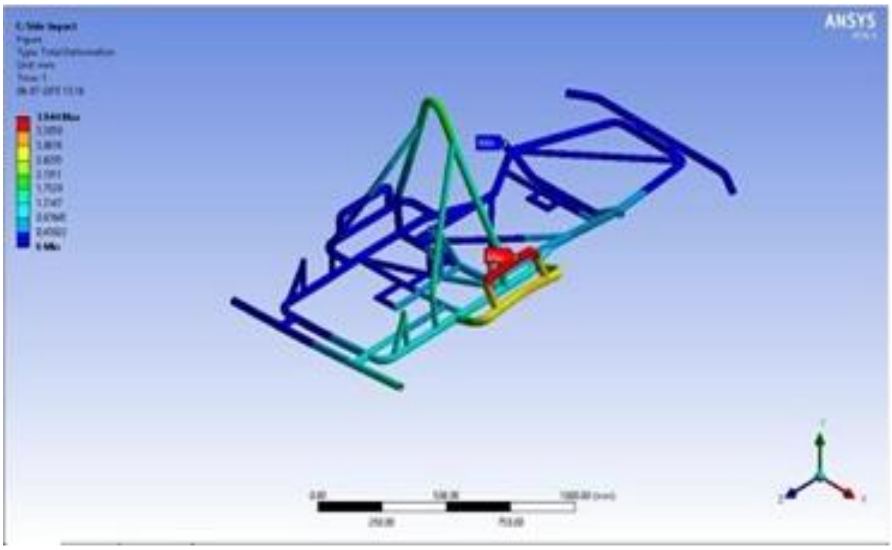

Figure 7 *Total Deformation*

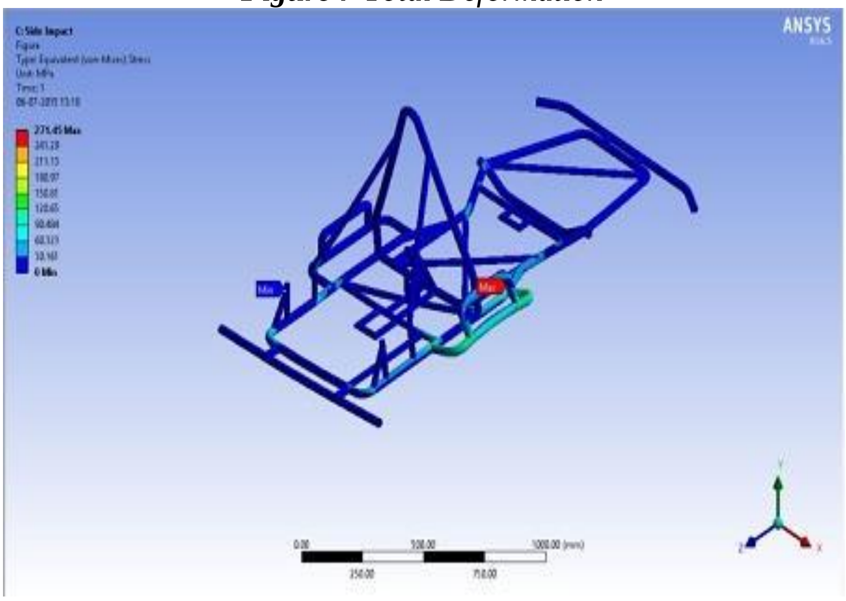

Figure 8 *Equivalent Stress*

Maximum Stress= 271.45 MPa

Now, Factor of Safety= Syt/Smax = 360/271.45 = 1.32

6. MANUFACTURING

6.1 Prototyping

After getting the right Factor of safety, the complete final chassis was drawn on the sheet without reduction and complete chassis was built with the help of PVC pipe.

At the fabrication spots, pipes were taped and at the bends, pipes were bent with the help of hot blow gun. The drawback of the floor planning (i.e. only 2D visualization) is over come in this prototyping procedure. Also, after the prototyping the extra members for the engine and driver's seat were decided if needed. Prototyping was also important for the preparing for the fixture to fabricate final AISI 1018 pipes.

Figure 9 *Prototype of the chassis*

6.2 Welding

The material which is used AISI-1018 has good weld ability. All welds on the vehicle are made using arc welding process. Arc Welding:

The arc welding is a fusion welding process in which the welding heat is obtained from an electric arc struck between the work (or base metal) and an electrode. The temperature of the heat produced by the electric arc is of the order of 6000°C to 7000°C. Both the direct current (D.C) and alternating current (A.C) may be used for arc welding, but the direct current is preferred for most purposes. When the work is connected to the positive terminal of the D.C welding machine and the negative terminal to an electrode holder, the welding set up is said to have straight polarity. On the other hand, when work is connected to negative and the electrode to a positive terminal, then the welding set up is said to have reversed polarity. The straight polarity is preferable for some welds while for other welds reversed polarity should be used.

Following are the two types of arc welding depending upon the type of electrode:

(A): Un shielded arc welding:

When a large electrode or filler rod is used for welding, it is said to be un- shielded arc welding.

(B): Shielded arc welding:

When the welding rods coated with fluxing material are used, then it is called shielded arc welding.

The process that we followed for complete welding process is explained below:

Firstly, the prototype model was placed onto the ply wood. The wooden block was nailed along the circumference of the PVC pipes.

The wooden block acted as a fixture. After the complete setup of the wooden block, the PVC model was replaced with the AISI 1018 pipes. The pipes were cut with the appropriate measurements and fish mouth operation was done on it on a bench grinder.

After placing all the pipes, spot was welded on the pipes and the partially welded was taken out of the fixture. After taking out the chassis out, the spot welding was replaced by run along the complete circumference. Two runs of welding were used at a time gap of twenty minutes in order to avoid the distortion caused due to expansion and overheating of metal.

7. CONCLUSION

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.

The designed go-kart is able to withstand against any adverse condition on road as it 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 id 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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