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Manuacturing and Testing of a Single Seater Off-Road Car.

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The objective of the study is to fabricate safest vehicle for a driver. The roll cage has been fabricated in accordance with SAE BAJA rule book. 3D Assembly of whole vehicle & Line model of the roll cage is modeled in SOLIDWORKS 2018. Different processes are used to manufacture different components with a view to cut back cost and achieve proper tolerances at same time.

INTRODUCTION

An Off-road car or All-Terrain vehicle (ATV) is essentially a Land based vehicle capable of reaching remote areas where normal cars/bikes cannot reach. ATV has a significantly good range of applications nowadays like in Military, Forest departments, Farming, etc. The project is to manufacture an ATV with different machining process, and making the entire assembly of an All-terrain vehicle.

A. ROLLCAGE

1. PIPE MATERIAL SELECTION

The material used for the vehicle roll cage is AISI 4130 (chrome-moly steel) i.e. chromium molybdenum alloy steel, on the basis of comparative study on parameters like material availability, Cost, Weight and Physical parameters. After comparing these following parameters with other steel grades like AISI 1018 and AISI 1020, AISI 4130 is comparatively best among them with the structure, maintaining the Integrity of the Specifications

2. PIPE SIZE SELECTION

In a view of gaining significant results in weight reduction, some changes were incorporated in pipe sizing. For the current car the diameter of the pipe was selected considering the equivalency calculations as per rules.

TABLE I

Pipe Sizing	(OD mm x thickness mm)
Primary	29.2 x 1.65
Secondary	25.4 x 1

3. MANUFACTURING

The manufacturing of Roll cage includes three processes that is pipe bending, pipe notching and welding.

a. PIPE BENDING

Pipe is bent for easy manufacturing of roll cage and avoid unnecessary welding of pipe wherever strong structure isn't necessary.

b. FIXTURES

To avoid unnecessary movement of pipe structure and accurate assembling of each member flex and metal fixtures were used.

c. PIPE NOTCHING

Pipe Notching is provided for correct seating of roll cage pipes enabling accurate assembly and welding of roll cage.

D. ARGON WELDING

Argon welding is employed for joining of roll cage members or pipes since it provides strength to nodes of pipes and avoid any failure

B. POWER TRAIN

The prime objective of the powertrain system is to attain a good velocity with high efficiency power transmission. The power train system must be able to deliver maximum torque from the engine to the wheel. Hence, continuously variable transmission (CVT) is chosen to attain maximum torque.

In addition to CVT it contains two stage reduction gearbox which is created from the Aluminum for a light weight housing of gears.

1. GEARBOX CASING

The gearbox casing is required for optimum operation of the gear drives. It provides ample lubrication, protection from environmental element and proper gear orientation. The material used for gearbox casing is Aluminum 6061-T6 considering its light weight, machinability and heat dissipation property. It is machined on CNC milling machine for proper fitting and compactness.

2. DRIVE SHAFT

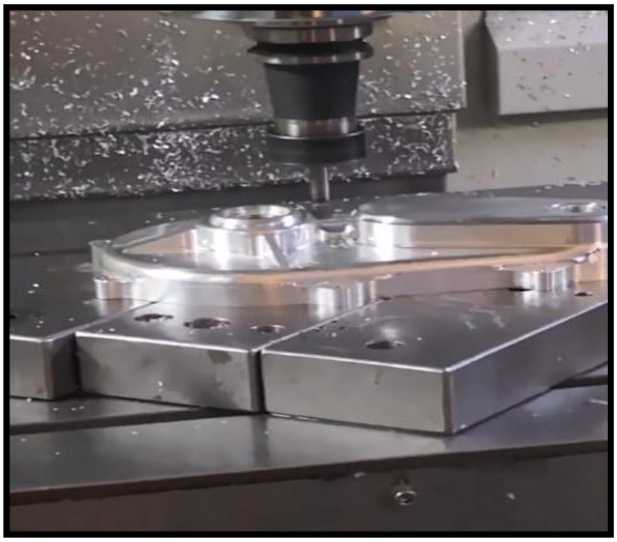
The drive shaft is customized to suit the requirement of the vehicle. Both the end of the half shaft contains CV joint. One end is connected with spool and another end is connected to wheel. The drive shaft diameter is selected after calculation and considering the maximum operating torque at spool end.

MANUFACTURING

Gearbox was manufactured from Aluminum alloy 6061-T6 block using VMC, other processes involved are turning, gear cutting and drilling for Gears.

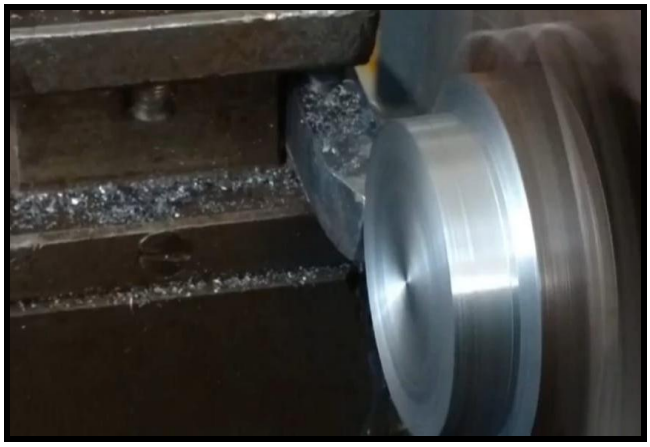
a. VMC MILLING

End milling and face milling process have been used for cutting process of gearbox casing. Around 4 hours was taken to complete these processes and a single block was used for both sides of casing to reduce the machining as well as material cost.



ONVENTIONAL TURNING

Conventional Turning on lathe machine of gears and shaft was performed to get required diameter and facing operation for length of shaft/thickness of gears.



c. GEAR CUTTING

After turning gear cutting and spline cutting is done to get required gear profile.

d. DRILLING

Drilling is done for removal of unnecessary weight form gears

e. TAPPING

Tapping is done for fastening of gear box casing and also for the mounting of rear brake caliper.

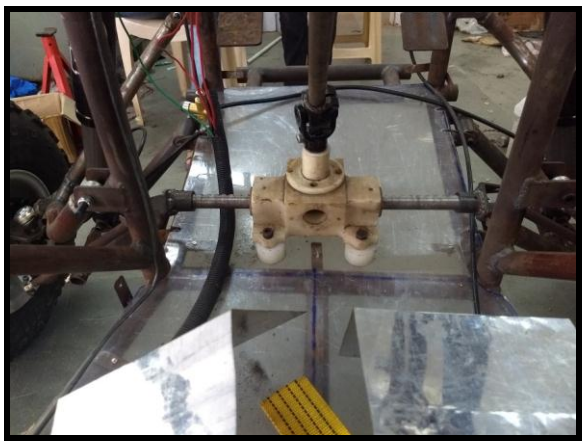
f. CASE HARDENING

Gears have been case hardened to in the range of 30-45 HRC up to 2 mm thickness.

C. STEERING

The design aim of the steering team was to ensure smooth maneuvering of vehicle during Corners. In order to achieve the ratio of vehicle wheelbase to track width is kept close to 1:1. Steering system hard points were first determined by considering the clearance and ergonomics.

EN-24 steel was selected as material for rack and pinion of the steering. For housing of rack and pinion, nylon 6 material for casing is used, as it is light in weight and easily machinable. Steering arm is made of P-40 steel for strength and durability of wheel assembly



1. MANUFACTURING

Different processes were used for complete manufacturing of steering system.

a. CONVENTIONAL LATHE

To get required dimensions of rack, pinion, tie rods and column lathe was used for the processes of turning facing etc.

b. TAPPING

Tapping was done on both sides of rack for assembly of Heim and ball joints.

c. GEAR CUTING

Gear cutting and spline cutting is done to get required gear.

d. CASE HARDENING

Gears have been case hardened to in the range of 30-45 HRC up to 2 mm thickness.

e. VMC MACHINING

End milling and face milling process have been used for cutting process of Steering casing. Around 1 hour was taken to complete these processes and a single block was used to reduce the machining as well as material cost.

f. LASER CUTTING

Laser cutting process was used for cutting of 4mm steel sheet for mounting brackets.

D. SUSPENSION SYSTEM

1. PIPE SIZE SELECTION

Diameter of the pipe was considered according to the equivalency design calculations.

TABLE II

Pipe Sizing	(OD mm x Thickness mm)
Secondary (Square/round)	25.4 x 1.5


2. MANUFACTURING

The manufacturing of suspension arms includes majorly two processes that is pipe notching and welding after preparing appropriate fixtures for proper seating of pipe members.

a. FIXTURES

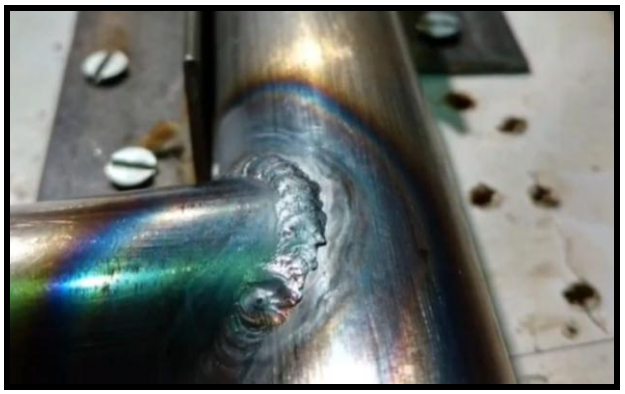
To avoid unnecessary movement of pipe structure and accurate assembling of every member flex and metal fixtures were used.

b. PIPE NOTCHING

Pipe Notching is done for proper seating of suspension arms for proper assembly and welding of pipes.

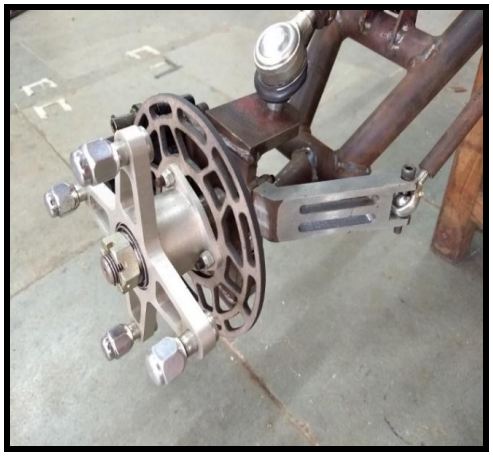
RGON WELDING

Argon welding is used for joining of suspension arms or pipes since it provides strength to nodes of pipes and avoid any failure.



E. HUBS & UPRIGHTS

Custom design uprights and hubs were used for Strength and durability of wheel assembly. P-40 steel is selected for high impact loads and high durability.

1. MANUFACTURING

Different processes were used for complete manufacturing of Wheel assembly components.

a. CONVENTIONAL LATHE

To get required dimensions of hub and wheel axle lathe was used for the processes of turning facing etc

b. VMC MILLING

End milling and face milling process have been used for cutting process of hub and knuckle. Around 6 hours overall was taken to complete these processes. A round bar was used for hubs and plate was used to reduce the machining as well as material cost.

F. BRAKES

The objective behind the braking system is to lock all the four wheels dynamically so as to to ensure the safety of the driver and maneuverability of the vehicle.

Brake rotors are custom manufactured to achieve the required output and to achieve design requirement for reduction of weight.

1. BRAKE ROTOR

In order to reduce the weight, slotted design of rotor was selected. According to those calculations effective radius of rotor was decided.

MATERIAL SELECTION

The parameters considered while selecting material for brake rotor are machinability, frictional property, hardness and resistance against rusting and wear etc. accordingly, SS304 is selected complying with market availability and cost.

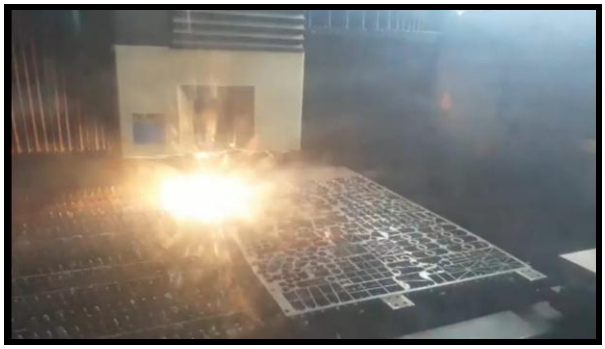
2. PEDALS

Over hanging assembly was selected considering driver comfort and position of steering system.

3. MANUFACTURING

a. LASER CUTTING

Laser cutting was used for cutting of brake disc and brake pedal.



G. FULL CAR ASSEMBLY

Step by step assembling of sub - assembly was carried out

1. Assembling of B&S engine, Gearbox and CVT
2. Assembling of body panels and covers.
3. Assembling of wishbones and Fox Shocks.
4. Assembling of uprights, brake rotors and hubs
5. Assembling of pedal assembly.
6. Assembling of steering system.
7. Assembling of seat and driver safety peripherals.

H. TESTING/VALIDATION

1. COMPONENT ACCURACY

Dimensional accuracy of components manufactured was done using Vernier calipers and micrometer. Other tests include physical and chemical test of raw materials.

TABLE III

Parameters	Technique	Acceptable Limit
Physical/chemical properties	UTM / PMI	Within yield limits / chemical composition
Welding	UTM	>70% strength of parent material
Dimensional Accuracy	Vernier Caliper	±0.5mm
RPM	Digital Tachometer	>328 rpm (43 kmph)
Braking Distance	Measuring Tape	Stopping Distance < 4m
Turning Circle Radius	Track Test	<1.8m
Gradeability	Static Slope	>30%

2. PERFORMANCE/TRACK TESTING

Various track tests include Maneuverability, Suspension and Traction, Acceleration, Hill climb, Sled pull and Endurance tests are performed on various terrains.

a. Maneuverability test is done to check car's turning ability at sharp corners.

b. Suspension and traction tests are done to check ability of car to withstand worst of terrain.

c. Acceleration tests are done to check speed and acceleration of car.

d. Sled pull is done to check power and torque of gearbox and transmission system.

e. Hill climb is done to test car's ability to overcome steep slopes.

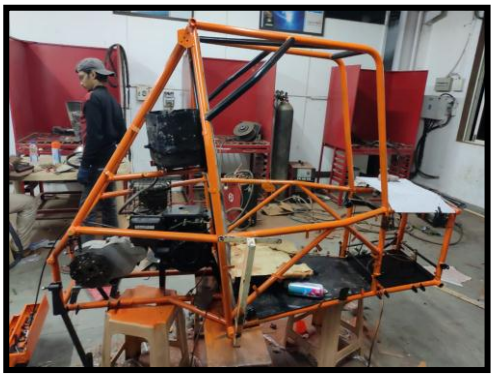
f. Endurance test is done for running car at least 500km to check whether the car can withstand rough terrains in full speed without any breakdown.




I. PAINTING, AESTHETICS AND FINALIZATION.

1. PAINTING

Painting of Car was done using simple spray paint cans with DFT (Dry film thickness) range from 15-20 microns.



2. ESTHETICS

Vinyl was printed and pasted on body panels to add to its aesthetic view.

3.FINAL PRODUCT

FRP (ie. Fibre reinforced plastic) seat, Driver safety restraints, Engine Kill Switches, Fire extinguishers are also installed in the car.

J. RESULT AND DISCUSSION

Fully functional All-terrain vehicle has been manufactured, assembled and tested successfully. The basic test results prove that car is safe for driver with respect to materials used. The track tests prove that car has speed of 52kmph, can maneuver through corners as tight as 0 turning radius, climbs hill with gradeability of 68%, stops within 4m patch when brakes applied at a speed of 52 kmph and can easily endure for 4 hours of rough terrain at max speed.

K. CONCLUSION

The chosen design was the safest and the most reliable car for any long terrain. All the parameters like safety, cost, performance, aesthetics, reliability, durability, standard dimensions and material were also taken in consideration on the same time. The vehicle was safe in all aspects and conforms with safety rules specified in BAJA SAEINDIA 2020 Rulebook.

L. FUTURE SCOPE

Major players in field of all-terrain vehicle are Polaris, Yamaha, Honda and most of are used for only recreation purposes in India. The all-terrain vehicles can have wide application in the field of agriculture, constructional and industrial applications where such type of car can be utilized up to its full potential. With minimum modification for each type of its application and with use of technology and automation all-terrain vehicles can be replaced with tractors and manufactured at cheaper rates than tractors.

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