Design and Manufacturing of Manual Transmission Car with Hand Operated Clutch

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***Abstract*: The main goal of this project is to make a ground up race car from scratch with a reliable, easy to maintain and repair approach. This car will also provide to be a test bed for different ideas such as the hand operated clutch and many more to come. The car should be light weight and the design should be driver eccentric. This project will also show the engineering methods used to build a race car, an accumulation of all the engineering knowledge acquired by the student in his entire engineering course. During this project the practical knowledge acquired by the students cannot be compared to the theoretical knowledge. The car will be a mid-engine rear wheel drive car that will be good at cornering and stable in the straights. The space frame design will give the car its rigidity and structural support with minimizing weight and cost. The engine used will be easy to work with, reliable, readily available. The spare parts for this engine are also readily available. The aim of this project is to minimize the lap time of car by eliminating the lift off of foot from accelerator pedal and then pressing the brake pedal and vice versa. This will allow the driver to brake late on the corner entry and accelerate fast as compared to other cars on the corner exit. This can be achieved by removing the clutch pedal from the driver's foot well and relocating it to the steering wheel or mounting it on the gear lever. This helps the driver to do acceleration and braking simultaneously without lifting the foot. In daily life this can be used as an option on the manual cars which are bought by the people with one leg disability. This can help them drive a car without any unnecessary cost increase in opting for the automatic transmission. As for now the automatic cars are more costly than their manual transmission variant.**

1. Introduction

In today's time to be a petrol head and to have a custom race car is very expensive. To go racing on racing track is a different story. Building a project car is an option. But this car is heavily depending on the base car that you start the project with. There are lots of complications that occur while building a project car. And if all goes well there is that additional weight to deal with. On the other hand there are those custom ground up build race car. But these are expensive and difficult to make as there is a lot of calculations and measurements to be considered. And not all petrol heads are engineers.

First automobile was patented on January 29, 1886 by Carl Benz. And this started a revolution in commuting. Things escalated quickly as a few individuals developed interest for going fast. And this began the era for automobile racing. Many inventions were made in order to give the driver an advantage in speed, braking, down force, acceleration, cornering etc.

2. Problem Statement

- In formula Bharat the teams use a manual transmission for their car, which has 3 pedals. So they have to lift off from the accelerator pedal and press brake pedal while entering a corner.
- This causes the driver to lose a few milliseconds of his timing. And these few milliseconds on every corner add up to a few seconds during complete lap.
- So by removing the clutch from the foot well and placing it on the gear shifter reduces a pedal so the driver can do acceleration and braking simultaneously, and gain those seconds and have an advantage in the dynamic testing round.

3. Objectives

- Make a race car with easy to replace and cheap parts.
- Reduce overall weight.
- Improve gear changing efficiency.
- Increase structural rigidity.
- Reduce lap times as compared to other counterparts.
- Make the car easy to use in real world conditions.
- Make post crash frame damage easy and cheap.
- Reduce fuel consumption.

4. Concept

➢ Car

We aimed to achieve high performance in comparatively low price by reusing the existing parts and trying to reduce the overall cost as low as possible. Also the car will be designed with the driver centric approach as the driver can use the car to its full potential.

The 3 concepts for the car are as follows:

- 50:50 weight distribution- this is done to reduce the under-steer and over-steer of the car. And to make the car take the apex in a desired racing line.
- Driving position near the center of gravity- this will help the driver to get connected with the car easily.
- Hand operated clutch so that the driver can use the accelerator and brake simultaneously to increase the lap timing. Pressurized chassis so that the post crash frame damage indication will be easy.

➢ **Gear Shifter Mounted Clutch Lever**

The gear shifter is accompanied with a lever style clutch. The location for clutch was selected as the driver's hands will already be there. Also by doing this the clutch pedal is removed from the foot well which makes one foot per pedal.

This will help the driver to brake later at corner entry and accelerate faster at the corner exit.

➢ **Pressurized Frame**

The idea behind this is that we can use the minimum limit of frame thickness to attain desired stiffness and if there is a crack in the frame then by the pressure change it can be detected.

This also makes the post crash frame integrity determination easy and cheap. As this does not need to remove all of the body panels in order to inspect the frame for cracks. They can simply use a compressor and pressure gauge for this purpose.

➢ **Anti Scrape Front Lip Design**

As the car is low due to its aerodynamics, the front lip is prone to scraping and damage in real world conditions. So to avoid this castor wheels can be used. They can be attached to the lower inside section of the front bumper with an easily removable approach, as when on the race track it can be removed for the uninterrupted under belly air passage.

5. Methodology

➢ **Frame**

For the frame ASTM A 106 Grade B mild steel tubes was used. The design of the tube space frame was simple due to its ease of construction and requirement of lesser tools for construction.

The tube specifications are

❖ Tube 1- outer dia. 42.2mm x wall thickness 3.56mm
❖ Tube 2- outer dia. 60.3mm x wall thickness 3.91mm

The tube 1 was used to build the structural parts of the chassis like driver cabinet, engine compartment and intermediate truss members. Whereas tube 2 was used in main roll over protection, front bulkhead and engine mounting plane.

The tubes were cut with an angle grinder, hand grinder and gas cutter. The welding was done by using MIG welding process.

The overall weight of the frame with the engine crate hard mounted in it is 173 kg. The frame has a low center of gravity about 35cm in front of the main roll protection and 24 cm above the floor.

The main roll protection is capable of holding 600 kg of weight in case of roll over.

➢ **Engine Refreshing**

The engine we got was a bit worn out and had a head gasket leakage. So while we had to remove the head we decided to do an engine refreshing. The cams and valves were cleaned. The cam springs were changed. The cylinders were checked for compression leak. The oil pan was removed and cleaned. The fuel injectors were changed as one of them was clogged up. The fuel rails were cleaned. The distributor was a bit faulty so replaced it with a correct distributor from the same model car. The air box was cleaned and air filter was replaced. And the throttle body was also cleaned and the main flap was replaced inside throttle body. The pretensioner spring was changed as it was a bit loose.

The flywheel was machined with a few holes in order to reduce weight. This helped us to remove more of the parasitic losses. It also meant that due to a lighter flywheel the engine will gain the maximum rpm faster and will also drop the rpms faster. An AP racing clutch was used which was a 3 spoke racing clutch with ceramic friction pads. This was also a weight reduction in clutch.

We also removed few parts from the engine in order to minimize the parasitic losses. We removed the ac compressor as we did not need it. We also removed the power steering oil motor as the car has a manual steering. This freed up about 8 to 10 H.P.

➢ **Exhaust System**

The exhaust system was a straight pipe short exhaust system which reduces the back pressure by a bit which helps in scavenging of the gases and helps to get a few more H.P. from the engine.

➢ **Engine Placement**

The engine was placed at the rear of the car inside the engine compartment on the frame that was hard mounted to the chassis. It was placed at a 15 degree tilt towards the front of the car. This was done to achieve a near 50-50 weight distribution. The engine was placed low to the floor to reduce the rolling angle and to minimize the shifting of CoG from the pre determined spot.

➢ **Suspension System**

The suspension system was designed and build inhouse. The front suspension was a double wishbone independent suspension. The tubes used for the A arms were ASTM A 106 Grade B MS tubes with outer dia. of 31.2mm and a wall thickness of 2.56mm. The castor camber and kingpin angle were made same as the stock car at the starting with a minimum camber of (+) 1.5 degree, camber of 14 degree and a toe in angle of 1 degree.

The rear of the car has a multi link independent suspension. The control arms and the links were made of the same tubes from above.

Both the systems were designed and made to accommodate the desire to change ride heights and camber whenever wanted.

➢ **Steering System**

The steering system was a manual steering system with steering rack from a Maruti Suzuki Alto 800. This is done to increase the tyre feedback to the driver, so that he can use the last bit of grip available to him at that time to overcome the corner.

The tie rod length was increased by 75 mm to accommodate the track width.

➢ **Fuel System**

The fuel tank was located at the rear end with a special bracket that would help cushioning the rear impact to the tank. The tank was also wrapped in a heat shield to avoid heat from the engine to seep into the tank.

The fuel lines were custom made with an internal dia. of 4.4mm. The fuel pump and filter was replaced with a new one. The injectors were also changed with a new fuel rail.

➢ **Cooling System**

The stock radiator was used with a bigger diameter fan. A custom shroud was made with movable flaps for increased back pressure to draw in more air while standing still. The radiator was fitted on the support bars of the main roll protection above the engine and the radiator lines were rerouted accordingly.

➢ **ECU**

The ECU was placed inside the driver's cabin behind the seat and in front of the firewall. The original harness was used (a new one) but the extra wires were cut off and sealed. The fuse box was also placed next to the ECU. After fixing the two in place, connections to the sensors and actuators were made.

The battery was situated behind the driver seat to further reduce the center of gravity and keep it as close to the floor as possible.

➢ **Seat and Seat Belts**

A custom sheet metal seat was made with minimum to no padding to keep the weight down. The seat was inclined with an angle of 120 degrees from the floor. This helped in the aerodynamics and provided space behind the seat to accommodate the battery and ECU.

A custom made 4 point seat harness was made with a quick release central plug. The seat belts were attached to the main roll protection truss and floor.

➢ **Hand Operated Clutch Lever**

The gear lever was designed with the clutch actuator mounted on it. For this we used a clutch lever from Apache 200 4V that was mounted on the gear lever. This specific lever was chosen due to its rigid design and strength. The mounting point was altered and welded in place to attain zero changes while using it. And the eye to accommodate the wire end was also machined to increased dia. to accommodate the bigger block.

➢ **Anti Scrape Front Castor Wheels**

A set of two castor wheels were welded in such a way that they will not turn on its own, i.e. they will stay straight. Then these modified castor wheels were attached to the front bulkhead without any height alteration as they provided enough height for the purpose.

6. Working

➢ **The Hand Operated Clutch**

- ❖ The cluctching action will be attained by pressing the lever mounted on the gear lever.

- A 25 cm sifter rod was made with holes to accommodate the clutch lever.
- The clutch lever used is from Apache rtr 200 4v as it has a good build quality and will not break under the increased force of the clutch.
- The hole for adopting the hub of the clutch wire is increased in diameter.
- As the driver shifts gear he will also press the lever which will disengage the clutch.

➢ **The Pressurized Chassis**
- The frame is completely ventilated internally so that it can be completely pressurised.
- The external venting points were sealed off after fabrication.
- A tyre inflating valve was added to the frame.
- Then it is pressurised wit nitrogen gas at 22 psi.

➢ **Anti Scrape Front Lip Design**
- As the car is low on the ground clearance, this makes it difficult to clear steep slopes and bumps.
- A simple set of castor wheels is fitted to the front of the car in order to avoid the damage to the front lip of car.
- The castors are fitted in such way that when there comes time when the lip will scrape the ground, the castors will eliminate this by rolling on the ground and lifting the car up.

7. Advantages and Limitations

➢ **Advantages**

❖ **Hand Operated Clutch**
- Significantly reduces the lap timings on race track.
- Can do acceleration and braking actions simultaneously.
- No lifting of foot from the pedals.
- Any person with a disability of one leg can drive the manual car with such a setup.
- Modifications to place the clutch wherever the driver feels suitable.
- Makes rev matching while downshifting easy and any driver with a little experience can drive it.
- Engaging and disengaging of clutch will be efficient.

❖ **Pressurised Frame**
- Helps in detecting cracks after any accident.
- Helps to determine structural integrity of the vehicle.
- Does not require to remove body panels to inspect the frame.
- Reduces cost of detecting damage as all you need is a compressor and a pressure gauge.

❖ **Anti Scrape Front Lip Design**
- It is cheap to replace the castor wheels rather than replacing the whole front bumper.
- Easy to install.
- Can be removed on the race track in order to attain an uninterrupted air flow under the car.

➢ **Limitations**

❖ **Hand Held Clutch**
- The driver will take a while to get used to it to use it at its full potential.
- Gear shifting will be a bit hard as the driver has to use an extra force to pull the clutch lever.

❖ **Pressurised Frame**
- If over pressurised the frame may burst open. (but this will take a lot of pressure to do so.)
- If it is filled with normal air there is a chance of internal rusting.

❖ **Anti Scrape Front Lip Design**
- Will interfere in the under body air passage which will increase drag.

8. Conclusion

By using the displayed techniques one can increase the chances of winning the Formula Bharat in dynamic as well as static tests. The solutions to the problems were made with a low costing approach and the availability of parts for this was abundant in the local market.

This will help a racing driver to achieve faster laps and a daily driver to drive his lowered vehicle without the fear of scraping and damaging the front lip.

Also the post accident frame integrity determination is made cheap and easy.

References

[1] A Book on Chassis Design By Herb Adams
[2] Sadjyot Biswal, Aravind Prasanth, Dr R Udayakumar, Shobhit Deva1, Aman Gupta, Design of a suspension system and determining suspension parameters of a medium downforce small Formula type car, Mechanical Department, BITS Pilani Dubai Campus, DIAC
[3] 2021 Formula Bharat Rules Booklet