Design and Fabrication of Quad Bike

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***Abstract*- The objective of our project is to design and fabricate an independent suspension quad bike. It is aimed to simulate a real world engineering design project and meet the associated challenges. It involves thorough planning and manufacturing tasks when introducing a new product to the consumer industrial market. Our primary focus is to design a single sitter high-performance off-road vehicle with independent double wishbone type suspensions that will impart ruggedness for the rough roads and provide with maximum safety and driver comfort. The reverse gear system is also installed in quad bike which provides the comfort to drive the vehicle. Due to use of reverse gear box it is easy to drive vehicle in reverse direction. The design is for safety of driver.**

***Key Words*- Quad Bike, Suspension, Reverse Gear System, Power Transmission, Braking System, Shock Absorber, Design, Fabrication**

1. INTRODUCTION

A QUAD bike, also known as quad, All Terrain Vehicle (ATV), is defined by the American National Standards Institute (ANSI) as a vehicle that travels on low-pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. As the name implies, it is designed to handle a wider variety of terrain than most other vehicles. By the current ANSI definition, Quads are intended for use by a single operator, although some companies have developed for use by the operator and one more passenger. These Quads are referred to as tandem ATVs. The early ATVs were mainly used for agricultural purpose only. But now the definition of ATV is changing. Many countries are allowing Quads as commercial vehicle, though with the regulations on its use and safety, Nowadays, ATVs are generally used in defence and sports application thus redefining the ATV. Now Quads are also coming with durable roll cages, higher ground clearance making it more rugged vehicle. Suspension system is an integral part of any vehicle as it provides stability, safety and comfort. The suspension system can be considered as the muscle of vehicle due to its strength and flexibility. The main objective of providing individual suspension system is to provide comfort by isolating passengers from the shocks transmitted through irregular ground surface, maintain traction on all terrains and also to enhance the ride of two component linkages and shock absorber. We have strived to self-design and manufacture most of our components while some have been readily bought from the market and customised as per our requirements.

2. RELATED WORK

In the design of today's vehicles there is a strong emphasis on reducing the vehicle weight and to lower the aerodynamic drag in order to leave the smaller ecological and economical footprint. This has shown to affect the crossing sensitivity for ground vehicles, which is important for handling and safety. Most engines have a single spark plug per cylinder, a notable exception being in aircraft where the complete ignition system is duplicated to improve reliability. The spark usually is provided by a battery and coil although until 1920 a magneto was often used. For a continuously variable transmission (CVT) to produce an improvement in fuel economy, it must be efficient and have wide span (range of ratio). There are two significant types of CVT systems: Van Doorne belt system and Torotrak system; both of which have been the subject of much development work. The steering system is mechanism on a vehicle that serves to regulate the direction of vehicle by means of deflecting the front wheel. It takes an astonishing amount of energy to de-accelerate moving vehicle - in fact it takes the same amount of energy to de accelerate from one speed to another as it would to accelerate between the two speed-except that we can decelerate faster because most of inertial force are working for us rather than against us.

3. ENGINE AND POWER TRANSMISSION

The engine used here is Bajaj pulsar 143 cc delivering more power, smoother operation, longer engine life and improved fuel economy. Excellent performer for mid-duty applications, ower is transmitted to the drive wheels with the help of chain drive for high efficiency and without any power loss. The weight of the quad bike is 176 kg, so that it cannot effectively be pushed backward by the seated rider. When challenged the rider can easily reverse the vehicle without getting down from the vehicle. For this purpose, we have used specially designed reverse gear box in quad bike. We can obtain the backward movement by shifting the hand lever of reverse gearbox. The power is transmitted to the rear wheels with the help of cast combination chain type of chain drive, which have high efficiency and life.

3.1 Reverse Gear System:

Needs of Reverse gear system:-

1. To eliminate the partiality and complexity nature over the handicapped peoples in the society.
2. To improve the tendency and ability of physical challengers to live with confidence and without considering the illness and disability.
3. To get back the hope of all handicaps to show the strength of them to society.

Fig.1: Reverse gear arrangement.

3.2 Scope of Reverse Gear:

1. To provide a better convenient chariot ride feel while driving on roadways to physical challengers.
2. Suitable for the persons who have problem in the leg.
3. Suitable for the persons who have problem in the ear.

3.3 Advantages of Reverse Gear:

1. It improves the safety.
2. It is more comfortable to the physically disabled person.
3. It gives more confidence to handicapped people to drive the vehicle.
4. Easy to make U-turn on the vehicle.
5. Easy to reverse the vehicle.

Fig. 2: Reverse gearbox installed in quad bike.

4. MATERIAL SELECTION

A high strength material is important to be used in roll cage as it needs to absorb as much energy as possible to prevent the roll cage material from fracturing at the time of high impact. The AISI 1020 Steel used for this purpose gains hardness and strength with proper heat treatment. This carbon steel is commonly used plain carbon steel. It has a good combination of strength and ductility. The chassis is the component for supporting all vehicles subsystems with the additional role of taking care of driver safety at all times. The chassis design is need to be prepared for impacts created in any certain crash or rollover. It must be strong and durable taking always into account the weight distribution for a better performance.

5. SUSPENSIONS

5.1 Objectives:

1. Designing a suspension that will influence significantly on the comfort, safety and manoeuvrability.
2. Contributing to vehicle's road holding and/or handling and braking for good active safety and driving pleasure.
3. Protect the vehicle from damage and wear from force of impact with obstacles.
4. Maintaining correct wheel alignment.

5.2 Design Methodology:

The overall purpose of a suspension system is to absorb impacts from coarse irregularities such as bumps and distribute that force with least amount of discomfort to the driver. This objective was taken care of by doing extensive research on the front and rear suspension arms' geometry to help reduce as much body roll as possible. Proper camber and caster angles were provided to the front wheels. The shock absorbers should be set to provide the proper dampening and spring coefficient to provide smooth and well performing ride.

5.3 Front and Rear Suspensions:

1. For our first suspension, we chose double arm wishbone type suspension. It provided spacious mounting position, load bearing capacity besides better camber recovery.
2. Front unequal non parallel double wishbone suspension.
3. The tyre needs to gain negative camber in a rolling situation, keeping the tyre flat on the ground.

Fig. 3: Double wishbone type suspensions.

5.4 Wishbone Arm (A-Arm):

Design for optimal geometry of the control arms is done to both supports the race weight of the vehicle as well as to provide optimal performance. Design of the control arms also includes maximum adjustability in order to tune the suspension for a given task at hand. The A-arms are constructed of 3 mm wall thickness 0.75 inch diameter round tube. FEA was also performed on the arms, and test simulations proved them to capable of handling the stresses exerted on them in extreme situations. Also kinematic analysis on the control arms was done as shown in the figure below to determine the dimensions of cross-section of control arms.

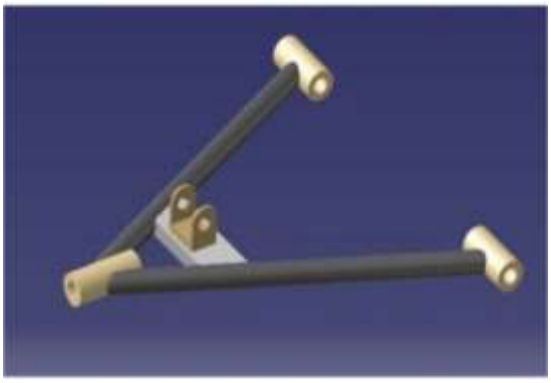

Fig. 4: Wishbone arm (A-arm).

5.5 FEM of Wishbone Arm (A-Arm):

Finite element analysis has also been conducted on the front arms. The stresses created in the part can be seen in Fig. 5. The biggest reason for choosing this design is that it only requires one piece, using a simple jig, to be fabricated. It has been determined that the tubing used for the suspension arms will be ASTM A106 steel. This was determined after comparing the weight and material properties for several sizes of tubings.

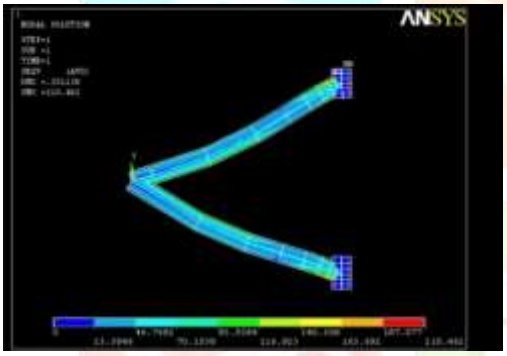

Fig. 5: Analysis of A-arm.

5.6 Shock Absorbers:

All the four suspensions are equipped with Honda unicorn monoshock absorbers which allows the automatic preload adjustment in order to keep the optimal vehicle trim. The shock absorbers provide the necessary stiffness needed by the swinging arm to maintain the ground contact as well as it is simpler in design, less unsprung weight which helps to reduce the overall weight of the quad bike and thus provide faster acceleration.

5.7 Design Calculations:

Initial data for shock Absorber:

Factors	Spring Index	Wire Dia (mm)	Spring OD (mm)	No. of Turns	Free Length of Spring (mm)
Front & Rear	4.512	15.8	71.3	10	254.6

Stiffness of spring (K) = $G*d^4 /8 D^3 n$

where,
G = modulus of rigidity
d = wire diameter in mm
D = spring diameter in mm
N = Number of turns
Spring force (Fs) = K * x
x = spring travel
Spring index (C) = D/d
Motion ratio = spring travel / 2* HCg
Design calculations results:

Factors	Spring Rate (kg/cm)	Roll Centre Height	Motion Ratio	Inclination
Front	22.01	22.109	0.73	66.9^0
Rear	383.38	0	0.25	62^0

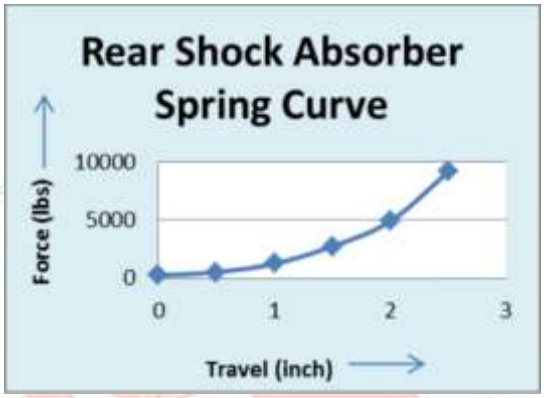

Fig. 6: Spring curve.

6. BRAKING SYSTEM

The purpose of the braking system is to increase the safety and maneuverability of the vehicle. In order to achieve maximum performance from the braking system, the brakes have been designed to lock up all four wheels at the same time. It is desired from a quad bike that it should have effective braking capability to negotiate on rigid terrains.

6.2 Disc Brake:

The braking system consists of three disc brakes, two in front wheels and one for rear wheel mounted on rear axle for requirement of effective braking at the rear.

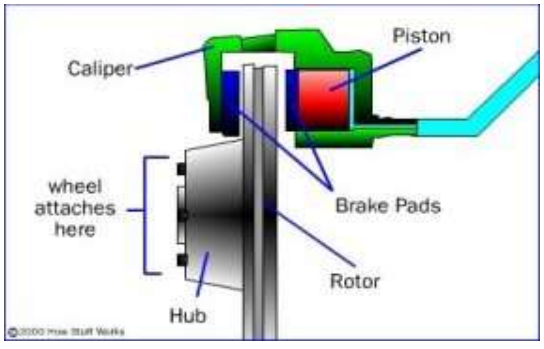

Fig. 7: Disc brake.

7. TYRES AND RIMS

Traction is one of the most important aspects of both steering and getting the power to the ground. The ideal tires should have low weight and low internal forces. In addition, it must have strong traction on various surfaces and be capable of providing power while in puddles.

Functions:

- Supports weight
- Transmit vehicle propulsion
- Soften impact from roads

Fig. 8: Tyre and rim.

7.1 Rim:

Selection of rim was the most crucial factor to be decided as knuckle, disc and callipers were to be placed inside the rim. So, proper space must be allocated in the rim to do so. Also, the weight of rim must be less in order to decrease rotational inertia of moving parts. So, the selection of rim size was done by design, suspension and braking department which had been discussed in their respective departments. The rims are made up of Aluminium alloy to minimize the unsprung weight.

7.2 Tyres:

Tyres were decided on the basis of final drive at axle and top speed required. It was also required to choose the tyre of less weight in order to decrease the rotational mass. So, tyres of size 24 x 8 -12 were used.

Fig. 9: Top view of tyre.

7.3 Hub:

The hub had to be bolted to the rim at one end and to the disc rotor of rear brake on the other. The hub is very important factor required to mount the wheels.

Fig. 10: Hub made of aluminium alloy.

8. BATTERY

The battery used in Quad bike is 12 Volt Amaron pro rider battery model number AP-BTX2.5L. The total weight of the battery is 998 gm.

Fig. 11: Battery

8.1 Electric Starter:

The modern starter motor is either a permanent magnet or a series or parallel wound direct current electric motor with a solenoid switch mounted on it. When usually from the starting battery is applied to the solenoid, usually through a key operated switch, it pushes out the drive pinion on the starter driveshaft and meshes the pinion with the ring gear on the flywheel of the engine.

9. DRIVER'S SAFETY & ERGONOMICS

Driver's safety is the most important concern for our Quad bike. For better perspective, we have made a safe model of quad bike according to the driver's ergonomics. For the comfort and well-being of the driver, the use of standard helmet, goggle, driver suit and shoes will be used to ensure driver safety. For the rugged up and down track the vehicle will be provided with a hitch point bumper with spring support installed in the front of the vehicle to absorb energy from collision.

The ergonomic features included the foam padding of the front, rear and side body panels, gear shifting indicator, turn light indicators, and standard rear view mirrors.

Fig. 12: Photo of the fabricated Quad bike.

10. CONCLUSIONS

The objective of designing and fabricating a single passenger off-road quad bike with high safety and low production costs have been accomplished. The design was first conceptualized based on personal experiences and intuition. Engineering principles and design processes were then used to verify and create a vehicle with optimal performance, safety and ergonomics. The objective of manufacturing quad bike with independent suspension system and reverse gear system has been successfully completed.

11. REFERENCES

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