Safety of All Terrain Vehicle used in Agricultural Field: A Review

Salunkhe S.B[1], Tawar N.S[2], Choudhary P.L[3], Kumar D.A[4], Mehta A.T[5]
[1, 2, 3, 4, 5] Department of Mechanical Engineering
[1, 2, 3, 4, 5]Sinhgad Institute of Technology, Lonavala, Maharashtra-410401, India.

Abstract-*All-Terrain Vehicles (ATV) this are day by day popular for both recreational and work applications. In Some countries all terrain vehicles are widely used in the farming environment. Recent statistics have indicated that high serious-injury and fatality rate is associated with rollover of Vehicle which are basically due to unbalanced centre of gravity associated with all terrain vehicle, So previously developed software for lumped-mass models could successfully simulate the rollover kinematics of all terrain vehicle, but the limitations in terms of effectively reproducing vehicle-rider contacts with the most common serious-injuries are related to chest and head. Software simulations can help to understand the vehicle-rider interaction during a variety of different rollover points (ROP). The objective of this research is to develop a model of a typical all terrain vehicles used in a farming environment which can overcome Roll Over Point by balancing the centre of gravity which helps in proper mounting of engine.*

Keywords-All-Terrain Vehicle (ATV), Roll Over Point (ROP), Loss of Control Unit (LCU), lumped-mass models.

I. INTRODUCTION

All-terrain vehicles (ATVs) are four wheeled vehicles which Travel on low pressure tires with engine sizes varying from 49 to1000 cc. ATVs have an inherently unstable design with a narrow wheelbase, short turning radius, high center of gravity and low tire pressure to maximize maneuverability. They travel at speed up to 120 km per hour or more depending on engine size and vehicle Design. Injury and fatalities secondary to ATV use have been documented. Worldwide since their invention in Japan in the 1960s and subsequent introduction to the U.S. in the 1970s. They are in popularly use in agricultural work due to their ability to handle a variety of terrain, light footprint and speed. ATVs have also gained popularity in competition racing, off road travel and recreation. Quad-bike vehicles, often called All-Terrain Vehicles (ATV's) these are four-wheeled vehicles designed to travel on a wide variety of off-road terrains. The rider straddles the vehicle similar to a two-wheel motorcycle ATV's are becoming increasingly popular for both recreational and work applications; in particular countries as these are widely used in the farming environment due to their versatility and contained size. Unfortunately, in some circumstances, ATV's can become particularly unstable because of their particular bike-type nature, especially if operated in a passive-driving mode (i.e., no active contribution of the rider with specific body movements in order to keep the vehicle balanced and in upright position).

Fig 1. All-terrain vehicles (ATVs)

II. LITERATURE REVIEW

Atv are used in agricultural, farm work and adventure sports. During the survey in U.S and Canada it was concluded that the number of` injuries and death gradually got increases in recent year. Quad bikes are extensively used in Agriculture. Estimated, 1 in 9 quad bikes loss of control event (LCE) result in farmer injury. Factors like age, height, weight, tires etc Spectrum of all –Terrain vehicle injuries in adults: A Case series and review of the literature by Elizabath c.,AislingHogan,Lynneclayin the year 2013.

The main cause of death in agriculture farm is over turning of quad bikes, tractors without ROPS. With the help of 3d programming, the factor which effect the AD-ROPS, can be overcome which effect the quad bikes and tractors. Installing air bag inflator. Development and validation of automatically deployable ROPS based onairbag inflator technology by Tomas ballesteros, Amaya, jose.l.arman in the year 2015.

Fractures are common injury among ATV crash victims. Taruma to head/brain is present in most cases. Precaution- licensing, use of helmet etc…Accident Analysis and Prevention by ward venlar, Heater macateer, Steven macaful in the year 2015.

All-terrain vehicles (ATVs) are gasoline or diesel-powered motorized vehicles, with oversize, low-pressure tires. The Consumer Product Safety Commission (CPSC), the federal agency responsible for regulating the safety of ATVs, conducts a yearly census of ATV rider deaths that occur on public roads, private roads, and off road. On-road all –terrain vehicle (ATV) fatalities in the united state by Allan F. Williams, Stephen L. Oesch, Anne T. Mccartt, Eric R. Teoh, Laurel B. Sims in the year 2014.

Reconnaissance ,surveillance and security application are time consuming, Tedious and potentially dangerous but critical to the success of military and other organizations.GPS are used in navigations It uses less expensive passive sensor and efficient perceptual detection and can run on standard pc. Distributed tactical surveillance with ATV by john M.Dolan, AshiteyTreby, Pradeepkhosla in year 1999.

ATV RISK FACTORS

A number of risk factors for ATV injury and death have been documented in the literature. While younger age and male gender are notable risk factors, most risk factors are modifiable behaviors of the ATV rider including: absence of helmet use, carrying passengers or riding as a passenger, riding the ATV on public roadways, and riding on ATVs with larger, more powerful engines not intended for use by children.

1. Younger age as a risk factor.
2. Male gender as a risk factor.
3. Absence of helmet use as a risk factor.
4. Riding as a passenger and carrying ATV passengers as a risk factor.
5. ATV riding on public roadways as a risk factor
6. Larger ATV engine size as a risk factor.
7. Balancing of Center of Gravity

III. CENTER OF GRAVITY CALCULATION

Locating the center of gravity of a vehicle is important for anticipating the vehicle's behavior in different situations. The easiest way to find the lateral and longitudinal coordinates of the center of gravity is to place the vehicle on four individual level scales. First, the track and the wheelbase of the vehicle are recorded. Then the weight at each wheel is recorded. The weight from each wheel and geometry are used in moment calculations to find the center of gravity in the longitudinal and lateral equations. This method is shown in more detail in Milliken's Race Car Vehicle Dynamics

The most difficult center of gravity coordinate to attain in a vehicle is the height. There are multiple methods to attain this parameter, one of which, is to lift the rear axle of the vehicle so the front to rear wheel centerline creates a certain angle,θ , with the horizontal. A diagram of this is shown in the following figure.

Fig 2. ATV

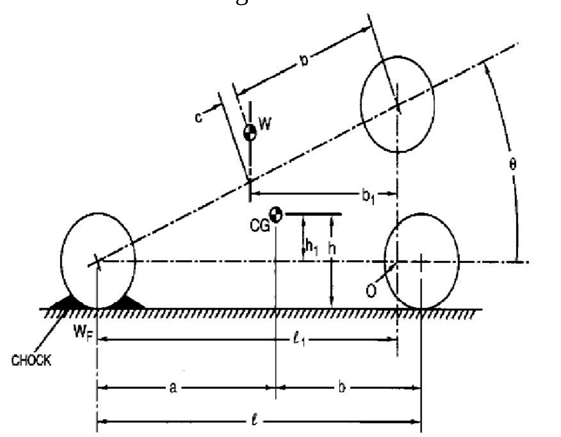

Fig 1. Reaction Method for Locating Vehicle CG Height

The new configuration will cause a shift in vehicle weight towards the front wheels thus presenting a new center of gravity position. Knowledge of the vehicle parameters such as radius of tire (RL),height of center of gravity(h),weight of frontaxle(Wf),wheel base of vehicle(l),total weight of vehicle(W),distance of rear wheel to the cog(b).

$$h = Rl + \left(\frac{WFl - Wb}{W \tan\theta}\right)$$

R is the radius of the front tires, W is the total weight of the vehicle, and F W is the weight of front of the vehicle during the test. A more complex equation is required if the front and rear wheels have different radii.

The above method of finding the center of gravity height can be used on a four post rig. The accuracy of test depends on the θ that is achieved in tilting the vehicle. In general a greater θ will achieve better accuracy. High accuracy can be achieved if the vehicle can be tilted forty degrees or more. More accurate results are produced for heavy vehicles,ones that weigh more than 1500 kg, than lighter ones. One advantage of using this method is that it requires very little specialty equipment. One simply needs vehiclescales and a way to lift the rear of the vehicle. If the vehicle can be lifted to high angles, forty degrees or more, accuracy of (±2%) can be attained for large vehicles. Other more difficult methods to locating the center of gravity height require special rigs.

Four different methods of finding center of gravity height are compared to each other in Error Analysis of Center-of-Gravity Measurement Techniques. The modified reaction method has already been discussed.

Null Point Method

The null point method requires a platform that has two parallel knife edges several inches apart from each other. In this method the vehicle is placed so the center of gravity is between the two knife edges. The vehicle is then tilted in either direction until the vehicle balances on one knife edge. This indicates when the vehicle CG has rotated outside the stable zone between the knife edges. Therefore, the CG height can be calculated from the two tilt angles. This method is more accurate than the modification reaction method, but requires a special rig.

Weight Balance Method

This method balances the vehicle on a rotating platform. Then a known mass is added to the platform to provide a torque. The amount the platform rotates will allow the height of the vehicle CG to be derived. Like the null point method, the weight balance method is very accurate, but requires a special rig.

Pendulum Method

The last method analyzed is the pendulum method. This method swings the vehicle at the end of a pendulum. Then the length of the pendulum arms is changed. Once again the vehicle is swung on the pendulum. The change in the period of the oscillation will allow the center of gravity of the vehicle to be attained.

IV. DEVELOPMENT OF THE ATV MODEL

Designing purpose of this Quad bike is to manufacture an off road vehicle that could help in transportation in hilly areas, farming field and as a reliable experience for a weekend enthusiast. In order to accomplish this task, different design aspects of a Quad Bike.vehicle were analyzed, and certain elements of the bike were chosen for specific focus. There are many facets to an off-road vehicle, such as the chassis, suspension, steering, drive-train, and braking, all of which require thorough design concentration. The points of the car I decided to specifically focus on were the chassis, drive-train, and suspension. The most time and effort went into designing and implementing these components of the vehicle because it was felt that they most dramatically effect the off-road driving experience. During the entire design process, consumer interest through innovative, inexpensive, and effective methods was always the primary goal.

LS-DYNAwas chosen as the FE software for simulating the ATV incident scenarios. This program specializes in modeling non-linear transient events such as crashes. It was selected as the most suitable choice because of its combined multi-body and Finite Element Method (FEM) capabilities. The vehicle modeled was a 2012 Honda TRX500FM ATV. The size and characteristics of this selected vehicle is representative of typical ATV's used for farming applications. Specifications of the actual ATV and the corresponding developed FE model are summarized. The vehicle geometry was obtained by digitizing the ATV surface geometry using laser scanning techniques. The vehicle was disassembled into various parts and each component was then scanned using 3D-scanners. The digitized surfaces were then meshed using shell or solid elements. The accuracy of the scanned surfaces allowed the geometrical and inertial properties of the actual reference 2012 Honda TRX500FM ATV to be reproduced with acceptable accuracy. All the vehicle components deemed necessary to correctly simulate the ATV kinematics, such as tires, steering system, and suspensions.

1. FRAME

The chassis is the component in charge of supporting all other vehicle's subsystems with the plus of taking care of the driver safety at all time. The chassis design need to be prepared for impacts created in any certain crash or rollover. It must be strong and durable taking always in account the weight distribution for a better performance

Table 1.Properties of material used in frame

MATERIL	1018 STEEL	4130 STEEL	4130 STEEL
OUTSIDE DIAMETER	2.540 cm	2.540 cm	3.175 cm
WALL THICKNESS	0.304 cm	0.30 cm	0.165 cm
BENDING STIFFNES	3791.1 Nm^2	3791.1 Nm^2	3635.1 Nm^2
BENDING STRENGTH	391.3 Nm	467.4 Nm	487 Nm
WEIGHT PER METER	1.686 kg	1.68 kg	1.229 kg

4130 Chrome Moly Steel is the best suitable material so following it we selected it over 1018 Steel because 4130 Steel has a greater strength to weight ratio. Along with material selection, tube diameter was also taken into consideration. Different sizes of tube were considered for the frame. It was decided to create the Roll Cage using 1 inch OD and 3mm wall thickness, 4130 Steel tubing as it was thought to be more structurally sound than a larger diameter tube.

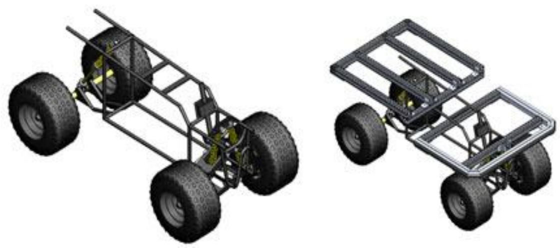

Fig 3. Design of frame

V. FRAME DESIGN CONSIDERATIONS

Table 2.Design parameter

CONSIDER A-TIONS	PRIORIY	REASON
Light weight	Essential	A light race car is a fast car
Durable	Essential	Must not deform during rugged Driving
Meet Requirements	Essential	Must meet Requirements to completes
Simple Frame	High	Majority of frame fabrication done in house
Attractive Design	Desired	Easier to sell an aesthetically pleasing vehicle
Cost	Low	Car needs to be within budget

Others things which are required for making quad bikes are :

1. TIRES

Since the operational tire pressure is only 4 psi, tires are effectively considered by manufacturers as an integral part of the design for both front and rear suspensions in ATV's. Given the low inflation pressure, tires of an ATV tend to undergo significant deformation both when the vehicle is ridden over obstacles and also during standard handling maneuvers.

Fig 4. Tires

2. BRAKES

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 rigid terrains.

Fig 5. Brakes

VI. DRIVER'S SAFETY & ERGONOMICS

Driver's safety is the most important concern for our ATV. For better perspective we have made a 1:1 PVC model of the roll cage and further improvised our design in CATIA according to driver's ergonomics. For the comfort and well-being of the driver, the use of standard helmet, goggle, driver suit, gloves, neck brace, shoes & fire safety equipment 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. Two Fire extinguisher and two kill switches specified in the rulebook will also be used for the case of emergency. Ergonomics include the foam padding of the front, rear and side body panels, gear shifting indicator, turn light indicators, standard rear view mirrors and such other things.

VII. CONCLUSION

Locating the center of gravity of a vehicle is important for anticipating the vehicle's behavior in different situations. A number of risk factors for ATV injury and death can be overcome by Locating Proper Center of Gravity which helps in avoiding the effect of Roller Over Point (ROPs).

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