International Journal of Engineering Research
Volume No.4, Issue No.12, pp : 640-642
ISSN:2319-6890)(online),2347-5013(print)
01 Dec. 2015

Tilting Mechanism for a Four Wheeler

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Abstract: Here in this paper a tilting mechanism is carried out for a normal fuel run track car to give it the flexibility of a motor cycle. This feature enables the car to tilt in to the curve while negotiating it. Our analysis shows that to increase the maximum curve at speed by more than 50%. The method we have used is a simple mechanical tilting system controlled by a simple DC stepper motor which is controlled electronically. This tilting mechanism if successful should dramatically increase the maximum speed in curves. This should also provide the advantages of increased passenger comfort and handling.

Keywords- curve, DC stepper motor, tilting

I. Introduction

Normal fuel run cars are without doubt the future of urban mobility. These cars have a very short wheel track in comparison to normal cars. Most of the international car companies have production models and prototype of normal track cars. Some examples are Nissan Land Glider, Nissan Pivo, Honda 3R-C, etc.

Such cars are mostly single seated or double seater with back to back seating configuration. These cars have several advantages:

1. Half the width means half the weight, more rigidity, more access to normal roads, easier parking and much quicker transit times.
2. In an electric vehicle, the lighter weight of this much smaller vehicle will help to enhance torque power characteristics of an electric motor to achieve “linear acceleration”.
3. At highway cruising speeds, such cars will be using half the frontal area and half the drag co efficient, plus reduced running losses make for a very energy efficient vehicle.

All these advantages make the normal track vehicle as appealing as an alternative to the car.

Such cars combine the comfort of a car with the functionality of a motor bike. But these cars have a very important and dangerous drawback. With a very comparatively normal track and heights almost equal to normal fuel run cars, these cars are very susceptible to rolling. As of now all such normal track cars are electrically driven and have a limited top speed and hence this drawback is comparatively negligible[i]. But sooner or later these cars will have to get highway cruising speeds. Then this drawback will be of grave importance.

An attempt was made to face this drawback. It was thought so if the cars have the functionality of a motor cycle, why not gives it the flexibility of a motor cycle. This gave use to the idea of an auto-tilting car. There have been many tilting body designs in rail but is done here is not just a body tilting, in it the car tilts as a whole. Recently there had been some development in making three- wheeled tilting cars like the carver, but only prototypes or concepts exist in the field of four-wheeled tilters.

II. Methodology

The objective of this paper is to successfully develop a design of a tilting mechanism for a normal fuel run tilting car. The mechanism is to be reliable, simple, cost-effective and practically feasible. The aim of this tilting mechanism is to provide banking to the car on unbanked curves, so as to enable added threshold speed on curves in comparison to a normal fuel run cars non-tilting car. This system is also supposed to enhance passenger comfort as the side force felt by passengers in a car taking a turn is comparatively less in a tilting car. Also in our purpose is the fabrication of a mini-prototype–a remote controlled toy car-to demonstrate the tilting in real world.

The methodology adopted to use standard and presently used components in design rather than to design all components from ground up. The advantage of this method is that, you do not have to spend ridiculous amount and time in testing the integrity of each part as they have already proved their worth.

III. Frame Design

The frame has been designed with parameters taken from an already existing and successful normal fuel run rack car. The entire suspension system has been redesigned and an additional tilting tyre holder was welded on the frame both at front and rear. The adoption of an already existing frame for our design ruled out the requirement of stress analysis. The frame is sure to hold on, even in case of most hostile conditions, as it is a tried and tested design. The frame design is shown in Fig 1.1. A new computationally–efficient control allocation strategy based on convex optimization is used to map the controller commands to the individual braking forces, taking into account actuator constraints. Simulations show that the strategy is capable of preventing rollover of a commercial van during various standard test maneuvers [ii].

The appropriateness for a simple model for design purpose is verified through simulations. The designed trajectory control considers vehicle stability limits and takes advantage of bicycle model flatness. Tilting speed and speed controllers are designed in sliding frame network[x].

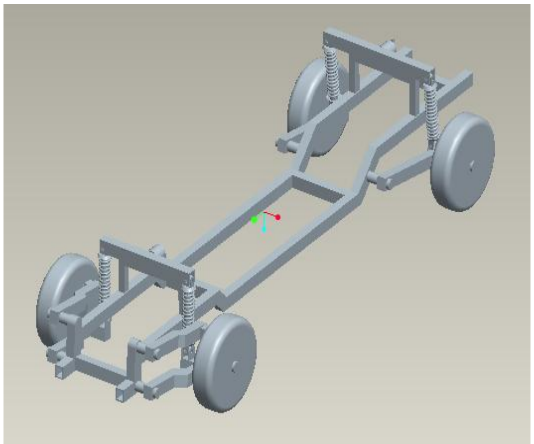

Fig 1.1

IV. Design of Tilting Mechanism

The tilting mechanism design was a complex question. Initially it was decided to use power screw driven, screw holders for each individual wheel controlled by a stepper motor. The design was almost completed. It had several advantages:

1. Each wheel could be moved independent of the other.

2. More precise control was possible with power screw lifters.

3. It could be modified to incorporate other systems like body level control, ground clearance adjustment system etc.

But analysis showed some critical disadvantages of screw lifters. They were;

1. Their response was slow at very high speed and repeated steering and control steering.
2. The wear and tear in screw parts was more than desirable. This would only aggravate in a real life situation where dust and sand particles can accelerate the wear of the screw and lifters.

Hence the design was discarded and the lookout for a new and simple tilting mechanism was carried out. It was at this point, it was decided to use the present design of a tilting mechanical tyre, controlled by a stepper motor. The ends of the tyre were linked to each rear wheel through struts as used in bikes rear shocks but with universal joints on both sides. The tyre is moved about a central pivot mount on the frame, this motion in result lifts the wheel on one side, while lowering the other and this in result tilts the vehicle to one side.

The reverse motion of the tyre tilts the vehicle in opposite direction.

After much thought and consultation, it was decided to power only the rear rotating tyre, the front was free and was supposed to follow the rear.

This was adopted not to reduce the cost but it had the following advantages:

1. It provided more freedom of movement to the front wheels, which ensured better comfort.
2. The freedom of movement of front wheels also give the vehicle added steer ability and maneuverability.
3. It also reduced the overall weight of the vehicle.

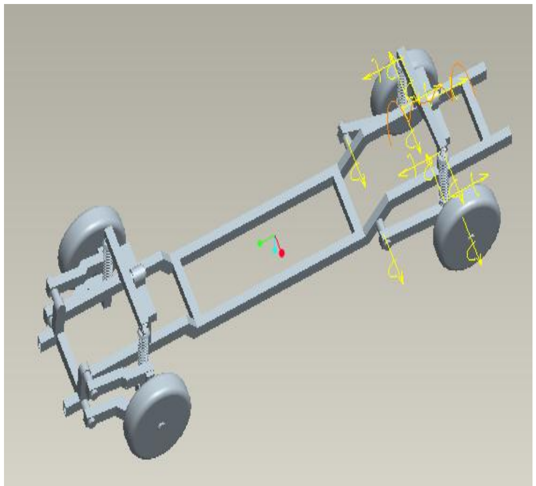

Fig 1.2

V Testing of Design

The designed tilting mechanism has been recreated and tested in Pro-E simulation program. Initially, the tyre resisted movement and after many rounds of fine-tuning the dimensions, the assembly began to show positive results. Only the rear rotating tyre had to be tested as the front was not under powered motion. The front rotating tyre assembly was also dimensionally modified to suit the rear one. Certain range of motion was imparted to the rear rotating tyre and the process was captured as a video for presentation.

The complete frame design with final dimensions

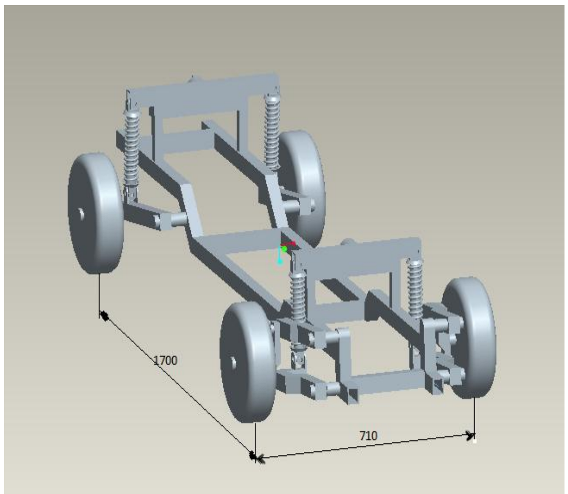

Fig 1.3

VI Comparison of Threshold velocity on curves for Tilting and Non-tilting Cars

From equations of vehicle dynamics, for a vehicle in a curve

Maximum sliding velocity,

$$V_s^2 = gC(\sin\theta + \mu\cos\theta)/(\cos\theta + \mu\sin\theta)$$

Maximum overturning velocity,

$$V_o^2 = gC(a\cos\theta + 2h\sin\theta)/(2h\cos\theta - a\sin\theta)$$

For a non-tilting car under the following parameters

$\mu=0.6$

$\theta=20^0$

C=50m

$g=9.8m/s^2$

a=0.71m

h=0.68m

Sliding velocity for non-tilting car =17.14m/s =61.7kmph

Overturning velocity for the same =15.99m/s =57.56kmph

Whereas for a tilting car that can tilt 20 degrees into the curve,

Sliding velocity = 24.58m/s =88.48kmph

Overturning velocity = 82.86kmph

Increase in sliding velocity = 43.4%

Increase in overturning velocity =43.9%.

VII Conclusion

It can be seen from the above result that, the objective to increase the threshold velocity of a normal fuel run cars in a curve has been successful. The design of the car and tilting mechanism worked flawlessly in simulation as well. The mini-prototype to demonstrate tilting is also working successfully, all these facts point to the completion of the objective in high esteem.

References

i) Salim Maakarounn., Wasima Khali.," Geometric Model of a normal Fuel Run Tilting Car Using Robotic Formalism.

ii) Benjamin Drew, Kevin Edge, Matt Barker, Jos Darling & Geraint Owen.,"System Development For Hydraulic Tilt Actuation Of A Tilting Narrow Vehicle".,The Ninth Scandinavian International Conference on Fluid Power, SICFP '05, June 1-3, 2005, Linköping, Sweden

iii) Gohl J- Rajamani R., Development of a Novel Tilting Controlled Normal Fuel Run Commuter Vehicle., Vehicle Dynamics And Control.,2003.

iv) N.K. GIRI. , Automobile Mechanics.

v) Chris Longhurst., "Suspension Bible.

vi) Reza N Jazar .,"Vehicledynamics.,PHI.,2008.

vii) Ulrich W Seiffert, Hans Herman Braess., SAE Intl.

viii) Handbook of Automation. Springer

ix) Fuzzy vehicle dynamic control

x) A low cost control mechanism for the improvement of vehicle roll over stability in turning maneuvers. ICMET2010

xi) Marcelo Gaudezi Di Faria, Enric Fossas colet.," A Siding mode controlled three wheeled Narrow Vehicle"Int.J. Vehicle design., Vol 62., Nos.2/3/4.,pp 123-146.