

Two Wheel Vehicle Self-Balancing Using Gyroscope

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ABSTRACT: Stabilization of a two wheeled vehicle plays a vital role in the complex transportation system. Gyroscopes can deliver a major contribution towards stabilization of two wheeler vehicle. It has been speculated that gyroscopically stabilized vehicles would have higher safety with respect to normal two wheelers. The dynamic stabilization of a two-wheeled vehicle requires that a torque acting on the vehicle naturally be neutralized by a torque produced within the vehicle by a gyroscope. The gyroscope here is used as an actuator, not a sensor, by using precession forces generated by the gyroscope. When torque is applied to an axis normal to the spin axis, causing the gyroscope to process, a moment is produced about a third axis, orthogonal to both the torque and spin axes. As the vehicle tilts from vertical, a precession inducing torque is applied to the gyroscope assembly and the opposing gyroscopic reaction moment will tend to correct the vehicle. The key idea is that motion of the gyroscope relative to the body is actively controlled in order to generate a stabilizing moment. We designed and fabricated a two-wheeler with self-balancing mechanism. The model works on the principle of inverted pendulum. The construction process includes the designing of the model in software, fabricating the model, assembling the model and testing. Battery is used as a power source.

I. INTRODUCTION

There are various types of parallel spin axis wheeled two-wheeler vehicles. They are typically used for commuting or for pleasure. Lighter vehicles with smaller engines are usually cheaper than their heavier counterparts and are the primary means of transport in a lot of Asian countries. Nowadays maximum road accidents are of the two wheelers. Needless to say, a lot of investment goes into manufacturing and development of state-of-the-art high technology motor bikes but none can guarantee road safety and it solely depends upon the rider and hence road accidents occur as the person riding the bike loses control over it and the bike falls. Also while learning to ride bicycles children are often afraid to ride as there is a fear of falling. To avoid such tragic scenarios, a mechanical gyroscope can be installed in the vehicles. It works on the principle of inverted pendulum and employs the use of electromechanical components which can be used as a means of transportation for a single person. The two-wheeled, self-balancing vehicle is a non-linear multivariable and naturally an unstable system. Controlling such a system is a hard task and thus it is the topic of research. It will move forward if the user tilts in forward direction and backward if the user tilts in backward direction. This paper presents a vehicle in which all components (mechanical, electrical) have been designed from ground up, produced, coupled together and tested. This vehicle can be viewed as ecological, battery operated and very easy to be used as system.

II. MODEL FABRICATION

The objective of this paper is to prove the fact that the a body can be balanced only on two parallel spin axis wheels in idle or running condition with the use of a mechanical gyroscope. The gyroscopic principle can be successfully used for creation of a prototype of a two-wheeled vehicle, and thus observing gyroscopic phenomenon on the same. The prototype was created using following parts:

1. Steel Frame
2. Steel Base
3. 12V DC Motor
4. Mild steel disc
5. Rubber Wheels
6. Nuts and bolts (M3, M5)
7. Ball bearings.

III. CONSTRUCTION

The gyroscope disc is manufactured using CNC lathe and drilling operations. The steel frame used is bolted on the bottom steel base. Round edge wheels are fitted to the steel base at the bottom, the holes in the frame are drilled in order to fit the gimble of the gyroscope assembly, the DC motor supported on a U bracket is placed on the gimble. The only pre-requisite for this setup to work is that the mass distribution, the mass should be dominant on the upper side (setup should be top heavy) of the gimble. The center of gravity is thus just above the gimble axis, stainless steel disc used as gyroscope are fitted to the shaft of the motor. The DC motor is bolted to the U-bracket due to which it remains intact with it and the shaft of the DC motor is fixed to a steel hub which has got holes drilled on its top flat surface to be used to finally fix the gyroscope disc by bolting it with the hub. The material used in making the gyroscope disc, hub, steel frame, and U-bracket is Mild Steel. To finally assemble the entire model, various sizes of nuts and bolts were used. One important design consideration that we made in this model is that the gyroscope disc should be freely suspended in the U-bracket connected to the steel frame. So for that, we used ball bearings and studs to make the angular movements and adjustments free and swift. The circlips are placed on the inner ends of the studs to avoid the studs to move out of the ball bearings, thus avoiding breakdown of the model during the running condition. The model has been made in such a way that the front wheel can move to take turns in order to change the direction of movement.

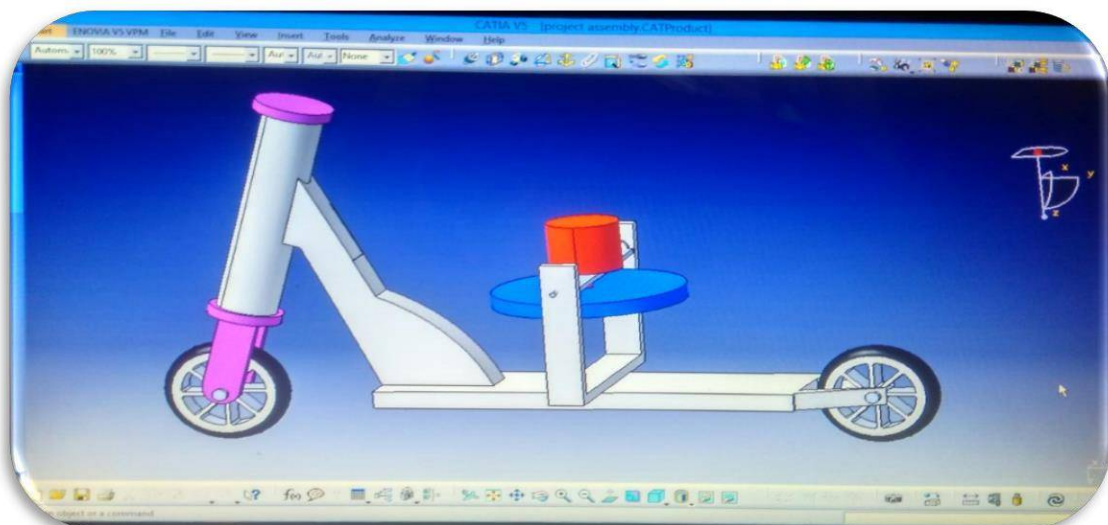


Fig : BLOCK DIAGRAM FOR PLACING GYROSCOPE

IV. WORKING

The model is powered by a power supply unit of 12V output. Once the motor starts rotating, the Mild steel disc fitted on the motor shaft starts to rotate and gradually gains speed. This rotation of the disc leads to the production of the gyroscopic effect thus, when the wheels lose their balance due to the active gyroscopic couple, a counter acting reactive gyroscopic couple is produced in the opposite direction due to gyroscopic effect, thus stabilizing the prototype model. This gyroscopic effect occurs on both left as well as right hand side. Thus, due to rotation of the gyroscope, a counter-acting reactive gyroscopic couple leads to the stabilization of the prototype. The motor and gimble axle assembly is designed in such a way that it is too heavy. This means that the center of gravity lies above the gimble axle. So the motor and gyroscope assembly tries to attain the position such that the center of gravity of the core will move downwards. But at the same time the motor and gimble assembly is arranged within the frame having bearing reaction at ends. So, the only possible way for motor to attain the stability is to either lean forward or backward. So, when the motor is started the body is about to fall on both side and also the motor assembly is leaning this causes the precession of spin axis. Due to this precession, according to right hand rule the reactive gyroscopic couple acts on the frame which nullifies the effect of the disturbing couple and thus stabilizes the vehicle. After few rotations and oscillations of motor, the motor and frame attains the stationary position and gyroscope is subjected to pure rolling motion about the spin axis.

V. APPLICATIONS

The above gyroscopic stabilization concept can be used in motor bikes for advanced stability and safety and also in bicycles and other such vehicles for safer transportation. The gyroscope assembly can be placed at specific locations in the vehicle to get the stabilizing effect. In addition to being used in compasses, aircrafts, computer pointing devices, missiles etc., gyroscopes have been introduced into consumer electronics. Since the gyroscope allows the calculation of orientation and rotation, designers have incorporated them into modern technology. The integration of the gyroscope has allowed for more accurate recognition of movement within a 3D space than the previous lone accelerometer within a number of smartphones. Gyroscopes in consumer electronics are frequently combined with accelerometers (acceleration sensors) for more robust direction- and motion-sensing.

VI. CONCLUSION

The final model of the self-balancing vehicle design is shown below. This design has been tested at different RPMs of the disc and also with different weights to see that the vehicle is balancing. This paper presents design and fabrication of the two-wheeler self-balancing vehicle which is capable of balancing itself under application of external forces and loads. The vehicle balances itself under various conditions like forced tilt of the vehicle. Thus the proposed system can be much helpful for two-wheeled vehicles reducing accidents or unwanted falls and increasing safety to the rider. This system reduces the work of humans as well as provides eco-friendly environment.

REFERENCES

1. Akshay Khot, Nishad Kumbhojkar, "MODELING AND VALIDATION OF PROTOTYPE OF SELF STABILIZING TWO WHEELER USING GYROSCOPE", Department of Mechanical Engineering, Sinhgad College of Engineering, Pune, Maharashtra, India
2. Stephen C. Spry and Anouck R. Girard, "Gyroscopic Stabilization of Unstable Vehicles: Configurations, Dynamics, and Control" March 31, 2008
3. Simos Evangelou "THE CONTROL AND STABILITY ANALYSIS OF TWO WHEELED ROAD VEHICLES" University of London, Electrical and Electronic Engineering Imperial College London September 2003
4. Ching-Chih Tsai, Hsu-Chih Huang and Shui-Chun Lin, "Adaptive Neural Network Control of a Self-Balancing Two-Wheeled Scooter," IEEE transactions on industrial electronics, vol. 57, no. 4, april 2010
5. Pierpaolo De Filippi, Mara Tanelli, Matteo Corno, Sergio M. Savaresi, and Mario D.Santucci. "Electronic Stability Control for Powered Two-Wheelers", IEEE transactions on control systems technology, vol. 22, no. 1, january 2014