Hub Centre Steering

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***Abstract* — As motorcycles get faster and faster the need for safety becomes specifically more important. The two most significant problems facing current front fork suspensions are lateral wheel displacement and extremely limited front wheel braking force. Hub center steering is designed to eliminate both of these problems. Although this project is built on a bicycle it is a proof of concept intended for larger scale applications. Previous iterations of hub center steering systems were analyzed as thoroughly as possible. A complete custom system was then created. The system was then checked with certain software's (Solid Works) for stress analysis. The system was then tested and proven to be a success. This hub center steering system has proven to work well to eliminate the major problems involved with front fork suspensions. Lateral wheel displacement is virtually eliminated and front wheel braking power is increased. This hub center steering system lays a great base of groundwork for the evolution of high speed motorcycle chassis design. The two most significant problems with high speed motorcycles can be alleviated with this design. As motorcycles increase with speed so should they with safety, this design opens that door. From basic design to stress point analysis this report contains the basic concepts required to build the safest and fastest motorcycle of the future.**

I. INTRODUCTION

The concept of Hub center steering has been around since the early 1900's and was first produced by Ner-A-Car. The Ner-A-Car was made under license by the Simplex Luxury Carmaker in Sheffield, England. The company lasted from 1921 to 1926 and went out of business due to lack of popularity. By the early 1950's hydraulically damped telescopic fork suspensions for motorcycles were becoming the standard. This was mostly due to improved ride over the un-damped systems used for hub center steering

Although telescopic front fork suspensions were gaining popularity and were very commonly used, this type of steering system was not without its own drawbacks. These drawbacks are exponentially increased as motorcycles get heavier and/or faster.

II. DRAWBACKS OF FORK SUSPENSION

A. *Effects of braking on the fork suspension*

With a fork the braking forces are put through the suspension, a situation that leads to the suspension being compressed, using up a large amount of suspension travel which makes dealing with bumps and other road irregularities extremely difficult. As the forks dive the steering geometry of the bike also changes making the bike more nervous, and inversely on acceleration becomes more lazy. Also, having the steering working through the forks causes problems with stiction, decreasing the effectiveness of the suspension. The length of the typical motorcycle fork means that they act as large levers about the headstock requiring the forks, the headstock, and the frame to be very robust adding to the bike's weight.

During the Static or Normal braking condition, the braking force and the reaction force from the contact point or ground compensate each other and the motorcycle is balanced. But in practical the Lever Arm is inclined from the steering head so, the braking force increases the bending moment and spring force is reduced. The force exerted at the steering head of the motorcycle while braking, also see figure 1. Not only does this require a larger frame to resist these forces, but these forces can cause a moment around the wheel and cause the motorcycle to flip over itself and injure and sometimes kill the operator.

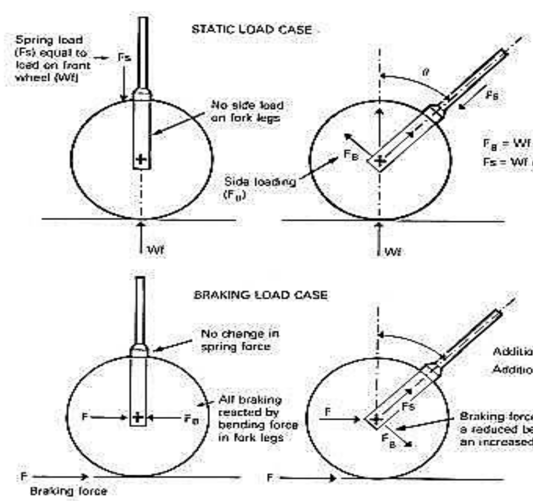


Fig: 1. force exerted at the steering head of the motorcycle while braking

B. *Effects of turn on the fork suspension*

Lateral flex in the fork legs which will cause the tire patch in contact with the ground to move away from the steering axis (lateral displacement)

This can cause the tire to wobble and the operator to lose control, refer fig: 2.

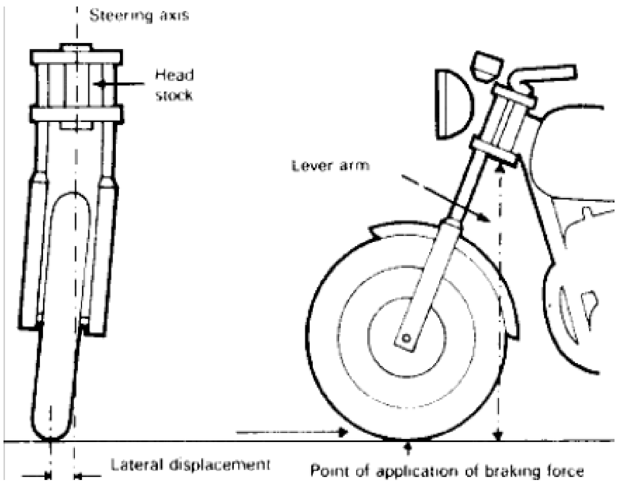


Fig: 2. Wobble of tire

III. Background

Hub-center steering is one of several different types of front end suspension/steering mechanisms used in motorcycles. Hub-center steering is characterized by a swingarm that extends from the bottom of the engine/frame to the centre of the front wheel instead of two forks. The advantages of using a hub-center steering system instead of a more conventional motorcycle fork are that hub-center steering separates the steering, braking, and suspension functions.

Hub-center steering systems use an arm, or arms, on bearings to allow upward wheel deflection, meaning that there is no stiction, even under braking. Braking forces can be redirected horizontally along these arms, or tie rods, away from the vertical suspension forces, and can even be put to good use to counteract weight shift. Finally, the arms typically form some form of parallelogram which maintains steering geometry over the full range of wheel travel, allowing agility and consistency of steering that forks currently cannot get close to attaining. The hub center steering's Achilles heel, however, has been steering feel. Complex linkages tend to be involved in the steering process, and this can lead to slack, vague, or inconsistent handlebar movement across its range.

Hub-center steering systems have only appeared on a very few production motorcycles, and not with any great success.

The hub-center steer concept is a very old one used as early as 1910 by the British James make, and in 1920 by Ner-a-Car, and enjoyed an aftermarket vogue in the 1970s through the work of Jack Difazio in the UK. The late Mike Tomkinson (of Mead & Tomkinson), aided by sons Chris and Patrick, pioneered the use of hub-centre steering in 24-hour motorcycle endurance racing. Their first machine, "Nessie" (qv), was powered by a Laverda 1000cc triple; but they later designed a Kawasaki-engined bike that became known as Nessie II. The Tomkinson's efforts encouraged Elf in the 1980s to create a succession of GP race bikes. In the 90's there was a flurry of action, first was the Bimota Tesi 1D in 1991 (designed by a young Massimo Tamburini of 916 fame) however this was expensive and was only ever produced in small numbers. Then in 1993 Yamaha launched the GTS1000 based on James Parker's RADD design. It raced at the Isle of Man TT but was always blighted with a reputation for being a bit heavy and clumsy in use. In 1995 Michael Tryphonos built a prototype based on the Defazio system that did race at the Isle of Man with some success reaching 11th in the Senior TT. Royce Creasey, designer of feet forwards motorcycles, is an ardent advocate of HCS.

Currently, Bimota's Tesi 3D and the Vyrus 984C3 2V and the 985C3 4V are the only production motorcycles using hub-center steering systems, however Italjet also use hub-center steering on their top of the range scooters. Sidecar manufacturers occasionally employ hub-center steering in their designs, such as the GG Duetto. An aftermarket hub center steering assembly is made by ISR Brakes of Sweden.

IV. ASSEMBLY

Hub consist of

- Outer Hub.
  1. Spoke Bracket with the disk brake.
  2. Roller Bearing.
- Inner Hub Assembly.
  1. Top Caps.
  2. Thrust Bearing.
  3. Centre Pin.

The inner hub consist of the Centre pin, thrust bearing for free rotation of pin inside the hub, top caps to cover the thrust bearing. Refer fig: 3.

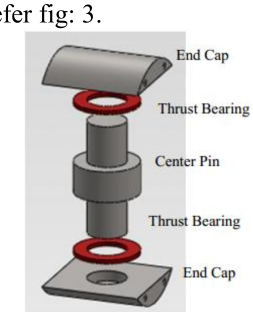


Fig: 3 Inner hub

The inner hub been assembled is now pressed into the inner cover of the roller bearing. The roller bearing and the spoke bracket comprises of outer hub of the assembly.

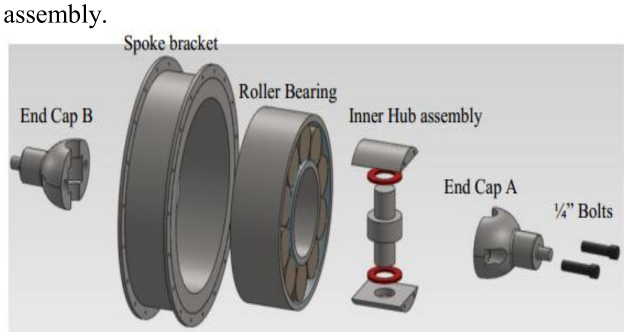


Fig: 4 Assembly of Inner hub in roller bearing

The end caps A and B are fasted over the centre pin with the help of ¼” Bolts.
Using solidworks software the stress points on the centre pin can be observed, and accordingly the metallurgical treatment is used to increase life of the hub.

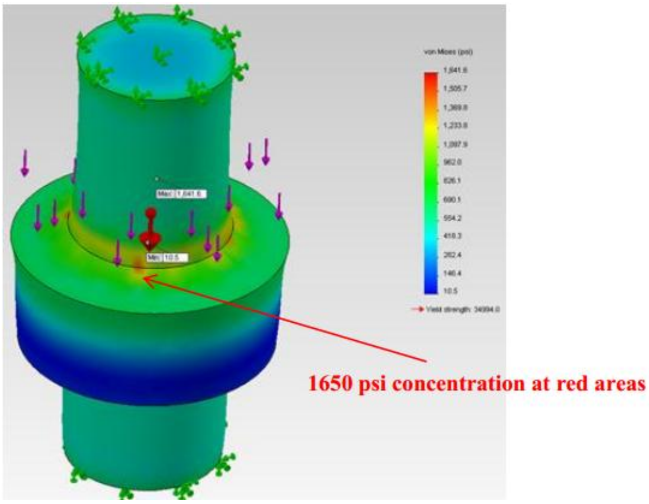


Fig: 5 Centre pin analysis

Table 1: Safety factor table

Component	Max Pressure (Ksi)	Yield Strength (Ksi)	Safety Factor
Frame	53.2	98	1.84
Center Pin	1.7	98	57.6
End Cap	22	98	4.5
Hex bolt	14	139	9.9
	Max Load (lb)	Allowable Load (lb)	
Thrust Bearing	500	1600	3.2
Roller Bearing	500	59500	119.0

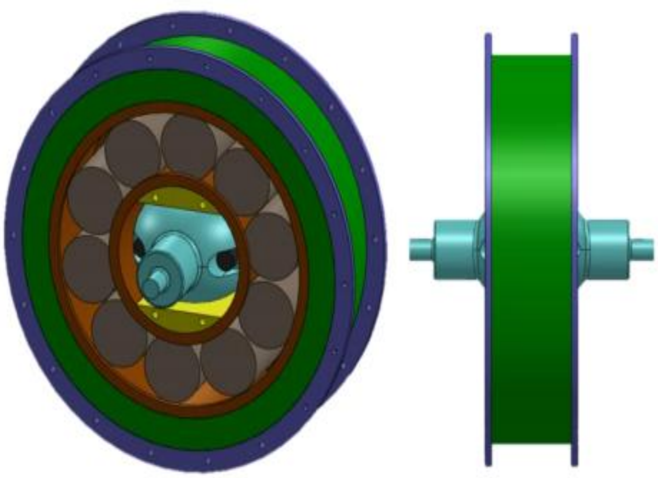
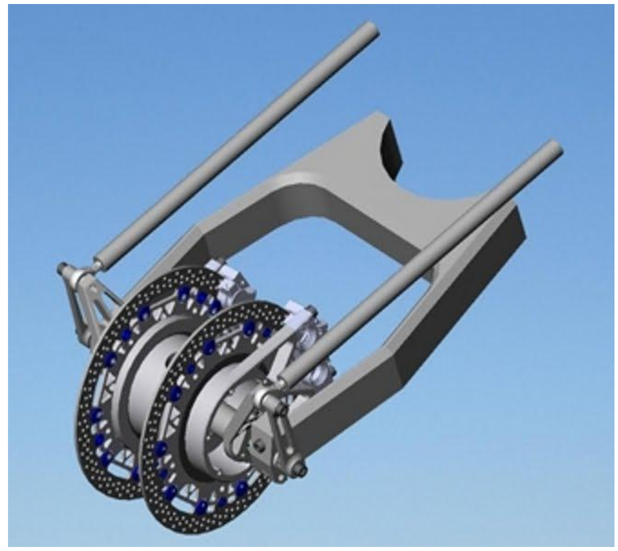
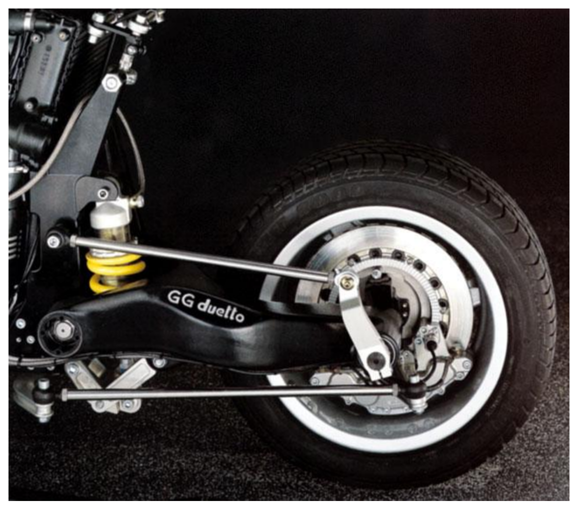


Fig: 6: CAD view of the Assembled Hub.

V. CHASIS DESIGN AND HUB POSITION



The swing-arm pinned at the ends of the end caps is hinged on the chasis frame at position above the lower level of engine for the proper suspension and steering action.



The swing arm and hub centre assembly ,with position of spring suspension and disk brake.

VI. Testing methods and results

1. The bike will be ridden for a prolonged period of time to prove it works.
2. Bicycle will also be flip tested and compared to a standard bicycle with a disk brake.

VII. Recommandation

The major problem arises in the rim brakes, as rim brakes are not capable of using maximum braking force available. Therefore disk brakes should be utilized which can be clamped rigidly to the spoke bracket.[1]

Bushing and bolts should be utilized instead of welds allowing for less tension at the joints.

It would be easiest to build a complete custom chassis instead of modify existing bicycles. It would allow for better fitment of parts and reduced weight as stress areas change with a hub center steering system.

VIII. Conclusion

Hub center steering is a great idea, but it holds limited applications. Removing lateral wheel displacement at high speeds is very important and increases safety exponentially. Secondly more useable braking power yields a shorter stopping distance which is always wonderful for both vehicle operator and bystanders.

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