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DESIGN, MODELING & SIMULATION OF HUB CENTER STEERING MECHANISM

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Abstract

Hub-center steering (HCS) is a type of front end suspension/steering mechanisms used in motorcycles. Hub center steering consists of a swing arm that extends from the bottom of the engine/frame to the centre of the front wheel instead of two forks. Hub center steering systems use an arm, or arms, on bearings to allow upward wheel deflection, meaning that there is no stiction or 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.

Keywords: Steering mechanism; hub center steering; front suspension design.

1. Introduction

The present motorcycles used two telescopic front suspensions for steering and suspension. As motorcycles get faster, the need for better steering control, suspension and braking becomes exponentially more important. The two most significant problems facing current front fork suspensions are:

A. Lateral wheel displacement and

B. Difficulty in maintaining control, especially during braking and negotiating a turn.

After so many years of telescopic forks use , people are used to riding a bike that handles in a specific way, and almost expect the limitations, and compensation is part of the experience.

With the rise in popularity in motorcycles, and the acknowledged problems of a front fork suspension, Jack Difazio saw a need for alternative steering systems. In 1968 there was a copyright made on the Difazio hub center steering concept.Difazio proposed the model for Hub centre steering mechanism.

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2. Construction & Working

Hub center steering is characterized by a swing arm that extends from the bottom of the engine or frame to the centre of the front wheel instead of two forks. 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

Finally, the arms typically form some form of parallelogram which maintains steering geometry over the full range of wheel travel, thereby increasing the control of the rider over the bike. This cannot be achieved by the conventional system. Generally a large diameter, steerable but non-rotating hub is mounted on a king-pin located within it. Another hub, of larger diameter, and forming part of the wheel, is mounted onto the first hub via large ball races. The centre line of the king-pin defines the steering axis, and so the only flexure that can allow the tyre to deflect away from this axis, is in the wheel and the hubs themselves.

3.Force Resolution

The forces that are acting on original bike frame are explained in the figure below

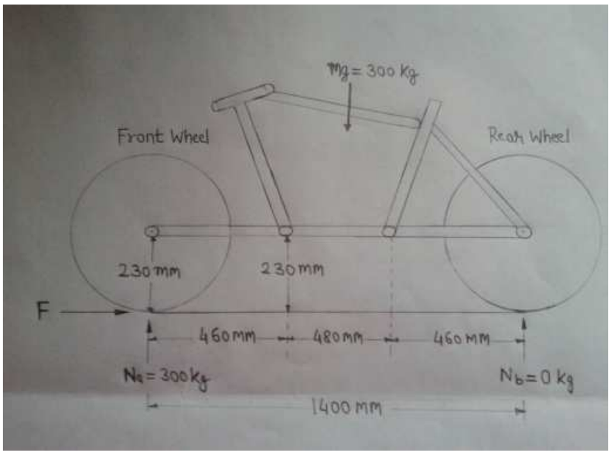

Figure 1: Force Resolution on Original Frame

The dimensions of the bike are considered from standard bike dimensions. The force resolution on original bike frame is calculated considering those dimensions.

Force resolution on original chassis when normal force on rear wheel is equal to zero.

Torque acting is too large and will break the Joint.

Torque from Rider sitting on Bike,

300 kg x 460 mm = 138 x 10^3 kg-mm

Stopping force required to create moment around front wheel,

$\Sigma m_a = 0 = (F \times 230 \text{ mm}) - (300 \text{ kg} \times 940 \text{ mm})$

F = 1226.087 kg-f

Torque created by stopping force on joint,

1226.087 kg x 230 mm = 282 x 10^3 kg-mm.

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4. Design Of Components

4.1 Design of Pin

Maximum Torque (T),
T= 282 x 10^3 kg-mm
T= 2766.42 x 10^3 N-mm
Considering material of Pin as Steel SAE 1030
Ultimate Strength = 527 Mpa
Factor of safety = 2
Shear Stress induced = Ultimate stress/factor of safety
= 527/2
=263.5 Mpa .
Diameter of Pin,
$\tau = (16 * T)/(\pi * d^3)$
$263.5 = (16 * 2766.42 \times 10^3) /(\pi * d^3)$
d = 40 mm
Length of pin,
L= 1.75 * d = 70 mm.

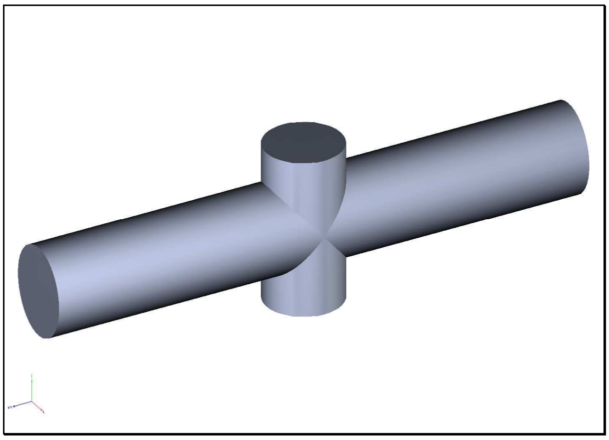

Figure 2: Centre Pin

4.2 Design of Thrust Bearing

Ratio of diameters,
(D/d) = 1.4
(D/40) = 1.4
Diameter of Thrust Bearing, D = 56 mm
Width, w = 15 mm

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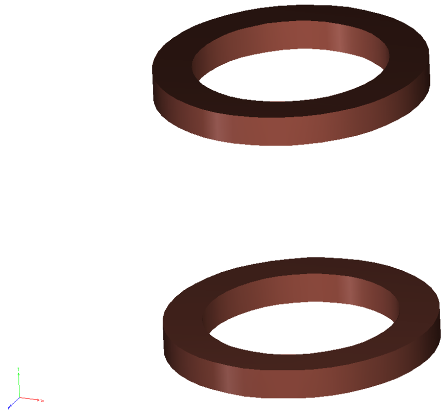

Figure 3: Thrust Bearing

4.3 Design of Cylindrical Roller Bearing

Bore Diameter = L + 2w = 60 + 30 = 90 mm
For Bore Diameter = 90 mm
Bearing Number = N218
Outside Diameter = 160 mm
Width = 56 mm
Dynamic Load Capacity, C = 129100
Axial Load, $F_a = N_a$ = 300 Kg
$N_a = F_a = 300 \times 9.81$
F_a = 2943 N
F_a = 2.943 kN

Radial load, F_r = F = 1226 kg
$F = F_r = 1226 \times 9.81$
F_r = 12.027 KN

Now,
$$\frac{F_a}{F_r} = \frac{2.943}{12.027}$$

$= 0.24 < 0.3$ (e = 0.3)

So, X = 1, Y = 2.5 (Considering for Spherical ball bearing)

Equivalent Load coming on Bearing, F_e
$F_e = (XF_r + YF_a)\, K_o\, K_r\, Ks\, K_{\varrho}$

Oscillation Factor, K_o = 1
Preloading Factor, K_{ϱ} = 1
Rotational Factor, K_r = 1
Service Factor, = Ks = 1

$F_e = (1 * 12.027 + 2.5 * 2.943)$
F_e = 19.38 kN
Life Of Bearing, L (in million revolutions life)

$L = (C / F_e)^{n} * K_{re}$

n = 10/3 for Roller Bearing
K_{re} = 1 for 90% Reliability

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$L = (129100 / 19.38 \times 10^3)^{(10/3)} * 1$
$L = 560$
Diameter Of Hub = 160 mm

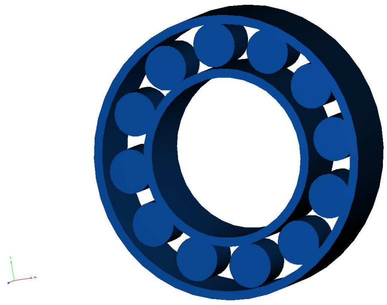

Figure 4: Roller Bearing

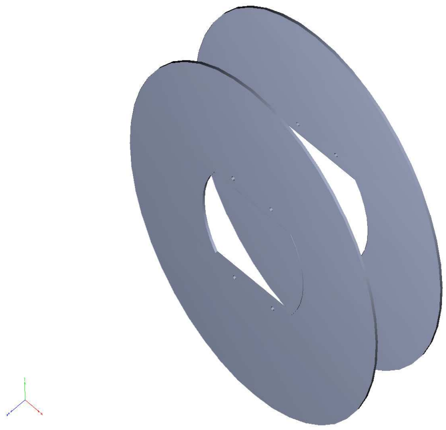

Figure 5: Bearing Cover

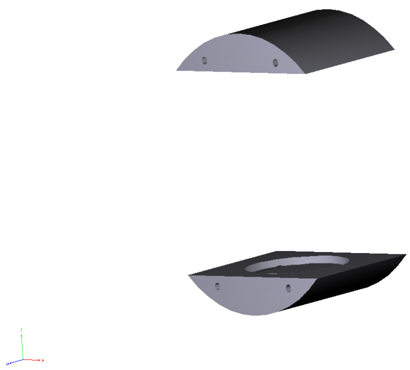

Figure 6: Pin End Cap

Figure 7: Swingarm

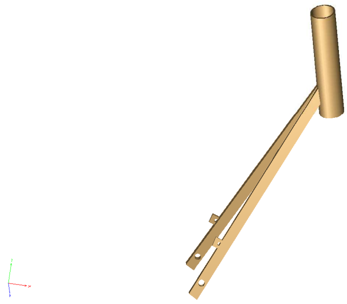

Figure 8: Frame

5. Assembly

5.1 Complete Assembly

Figure 9: Assembly

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5.2 Assembly in Exploded View

Figure 10: Assembly in exploded view

6. Advantages

- The source of lateral displacement (relative to the steering axis) is reduced.
- Braking efficiency is increased as braking loads are spread between the bottom swing-arm and the top steering links.
- Hub-center steering separates the steering, braking, and suspension functions.
- As compared to conventional design, HCS can provide longer wheel base.
- The ride quality is improved as better suspensions can be used (mono shock absorbers).
- Eliminates the use of a steering damper/steering stabilizer.
- Useful when the conventional type of steering mechanism cannot be mounted due to the position of front wheel.
- This may be a requirement for certain bike designs (aerodynamic, electric bikes).

As the system is not widely used, it may be accepted by customers looking for unconventional bike design.

7. Disadvantages

- As all the sideways rigidity is provided by the king-pin, this part is quite highly loaded when the wheel is subject to a lateral force

- It is a fairly complicated system as large number of components are used.

- Cost of the system is high.

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