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Increasing the Effect of Normal Reaction of the Two Wheelers While Braking at High Speeds

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***Abstract*— Each and every parts of a two wheeler has been designed well even though some times the braking system of a two wheelers shows poor performance. When the vehicle comes without brakes it turns the passengers into unsafe situation while riding the vehicle. So we should have a brake in our two wheelers which must deliver an optimum performance. The braking force is mainly depends on the following two factors one is normal reaction of the rear wheels and another one is coefficient of friction between road and tyres. Whenever the vehicle is loaded the normal reaction of the rear wheels also increases. So there is only minimum braking force is requires stopping the vehicle. When the vehicle is running at high speed with fewer loads it will become out of control. If we apply brake in this condition it will make a heavy injury, because the kinetic energy of a vehicle while running stored its total mass. So we need some weight while braking for increasing the factor of normal reaction. But when the vehicle is driven by single, it is not possible to get required weight in rear wheels. If we could some mechanical arrangement with rear braking system, which works with it too for getting normal reaction even fewer weight condition can minimizing the skidding phenomena.**

***Keywords*— normal reaction, internal expanding shoe brakes, friction, torsional spring, gear, transmission system, stopping distance.**

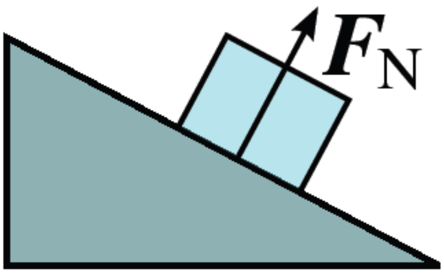
I. INTRODUCTION

In India wide range of peoples uses two wheelers for their transporting purpose. Mostly 100 and 125cc bikes are takes role with the Indian peoples. This bikes are coming with drum brakes only to their both wheels, sometimes the 125cc bikes front wheel have disc brake but it is also not efficient at high speeds. The main reason of the two wheelers skidding is its stopping distance which is getting large number of value at sudden braking in high speeds. Why the stopping distance has large number of value during braking at high speeds is the normal reaction of the rear wheels which is getting minimum value at high speeds with fewer loading condition. The pillion load has a relation with normal reaction of the rear wheels.

When the pillion load increases the normal reaction of the rear wheels also increases, its slightly decreases when the load decreases. But it is not possible to take a pillion load with the two wheeler permanently. Because too much of load will disturb the engines pulling power and reduces the engines performance too. Then how will we increase the normal reaction is adding a mechanical arrangement with rear wheel brakes which helpful to increase the normal reaction while braking means disturbing the free flow rotation of the rear wheels and transmission system by introducing a mass which only shows their performance during braking at high speeds.

II. NORMAL REACTION OR FORCE

In mechanics, the **normal force** *Fn* is the component, perpendicular to the surface (surface being a plane) of contact, of the contact force exerted on an object by, for example, the surface of a floor or wall, preventing the object to fall. For example, consider a person standing still on the ground, in which case the ground reaction force reduces to the normal force. In another common situation, if an object hits a surface with some speed, and the surface can withstand it, the normal force provides for a rapid deceleration, which will depend on the flexibility of the surface.



FN *represents the normal force*

Fig. 1. Normal force

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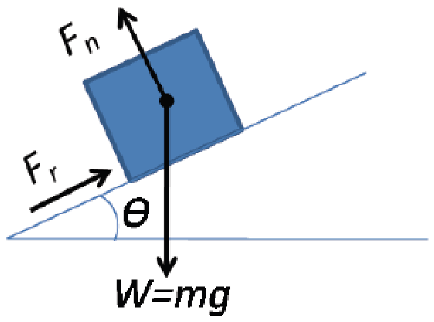
2.1 EQUATIONS



Weight (W), the frictional force (F_r), and the normal force (F_n) impacting a cube. Weight is mass (m) multiplied by gravity (g).

Fig.2.1. Equation for normal reaction

In a simple case such as an object resting upon a table, the normal force on the object is equal but in opposite direction to the gravitational force applied on the object (or the weight of the object), that is, $\boldsymbol{N = mg}$, where m is mass, and g is the gravitational field strength (about 9.81 m/s2 on Earth). The normal force here represents the force applied by the table against the object that prevents it from sinking through the table, and requires that the table is sturdy enough to deliver this normal force without braking. Where an object rests on an incline, the normal force is perpendicular to the plane the object rests on. Still, the normal force will be as large as necessary to prevent sinking through the surface, presuming the surface is sturdy enough. The strength of the force can be calculated as: $N = mg\cos(\theta)$ where N is the normal force, m is the mass of the object, g is the gravitational field strength, and θ is the angle of the inclined surface measured from the horizontal. The normal force is one of several forces which act on the object. In the simple situations so far considered, the most important other forces acting on it are friction and the force of gravity.

III. LITERATURE SUREVEY

Mansour Hadji, Hosseinlou, Hadi Ahadi and Vahid Hematian [1]. A large number of studies have shown that accidents on vehicles are the root cause of millions of death each year. Especially, two wheeler accidents are increasing rapidly when compared with four wheeler accidents. Two wheeler accidents are mainly due to sliding and increased stopping distance as two wheelers are less stable when compared to four wheelers.

Lee, C-H., Lee, J-M., Choi, M-S., Kim, C-K. and Koh, E-B[4]. The stopping distance of a two wheeler is the distance between a point where the brake is applied and to the point where linear velocity of the two-wheeler becomes zero.

In order to reduce accidents, minimum stopping distance should be achieved. It is accomplished with the help of maximum deceleration of the vehicle. This maximum deceleration depends on maximum braking force

Hans-christofklein[3]. If the braking force exceeds the maximum friction limit between tire and ground, sliding will occur due to the locking of wheels.

Mansour Hadji, Hosseinlou, Hadi Ahadi and Vahid Hematian [1]. Normal reaction on the tire is one of the key factors to be considered for varying the braking force. Because the braking force mainly depends on co-efficient of friction between the tire-ground and normal reaction on the tire.

Ebner H. and Kuhn, W[6]. As the effective radius of the disc increases the braking force increases in accordance with the pillion load on the two wheeler. The optimum braking force which helps in attaining minimum stopping distance without sliding is obtained.

Jimenez and Felipe[2]. During the deceleration phase, the load on the front wheel increases while the load on the rear wheel decreases, due to load transfer effect.

Hans-christofklein[3]. The braking coefficient is the level of tire-road friction needed by the braked tire so that it will just not lock up. The braking coefficient varies when either braking force or dynamic axle normal force changes and, consequently, it is a vehicle geometry and deceleration-dependent parameter

Chin, Y. K., Lin, W. C., Sidlosky, D. M. and Sparschu, M. S[5]. Anti lock braking system helps in preventing the vehicle from sliding but it does not reducing stopping distance for varying speeds at varying loads. But this system achieving minimum stopping distance.

IV. BRAKE

A brake is a device by means of which artificial frictional resistance is applied to a moving machine member, in order to retard or stop the motion of a machine. In the process of performing this function, the brake absorbs either kinetic energy of the moving member or potential energy given up by objects lowered by hoists, elevators etc. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in the surrounding air so that excessive heating of the brake lining does not take place. The capacity of a brake depends upon the following factors:

a. The unit pressure between the braking surfaces.
b. The coefficient of friction between the braking surfaces.
c. The peripheral velocity of the brake drum.
d. The projected area of the friction surfaces.
e. The ability of the brake to dissipate heat equivalent to the energy being absorbed.

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V. Materials For Brake Lining

The materials used for the brake lining should have the following characteristics:

a. It should have high coefficient of friction with minimum fading. In other words the coefficient of friction should remain constant with change in temperature.
b. It should have low wear rate.
c. It should have high heat resistance.
d. It should have high heat dissipation capacity.
e. It should have adequate mechanical strength.
f. It should not be affected by moisture and oil

VI. Types Of Brakes

The brakes according to the mean used for transforming the energy by the braking elements, are classified as:

a. Hydraulic brakes
b. Electric brakes
c. Mechanical brakes

In this article we have been seeing about two wheelers brakes so we only consider about mechanical brakes.

VII. Mechanical Brakes

The mechanical brakes, according to the direction of acting force, may be divided into the following two groups:

(a) *Radial brakes:* In these case brakes, the force acting on the brake drum is in radial direction. The radial brakes may be sub-divided into *external brakes* and *internal brakes.* According to the shape of frictional elements, these brakes may be *block* or *shoe brakes.*

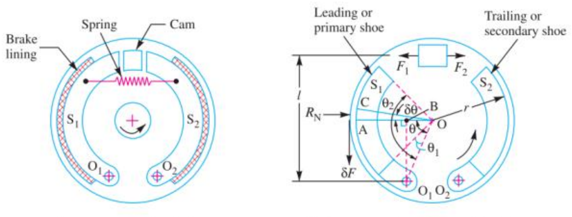
(b) *Axial brakes:* In these brakes the force acting on the brake drum in the axial direction. The axial brakes may be disc brakes and cone brakes. The analysis of these brakes is similar to clutches.

Since we are concerned with only mechanical brakes, therefore, these are discussed especially radial brakes.

VIII. Internal Expanding Brake

An internal expanding brake consists of two shoes S_1 and S_2. The outer surface of the shoes are lined with some frictional material to increase the coefficient of friction and to prevent wearing away of the metal. Each shoe is pivoted at one end about a fixed fulcrum O_1 and O_2 and made to contact a cam at the other end. When the cam rotates, the shoes are pushed outwards against the rim of the drum. The friction between the shoes and the drum produces the braking torque and hence reduces the speed of the drum.

The shoes are normally held in off position by a spring. The drum encloses the entire mechanism to keep out dust and moisture



(a) Internal expanding brake. (b) Forces on an internal expanding brake.

Fig. 8.1. Internal expanding shoe brakes

Let

r = internal radius of the wheel rim

b = width of the brake lining

p_1 = maximum intensity of normal pressure

p_N = normal pressure

F_1 = force exerted by the cam on the leading shoe

F_2 = force exerted by the cam on the trailing shoe

Now for leading shoe taking moments about the fulcrum O_1,

$F_1 * l = M_N - M_F$

And for trailing shoe, taking moments about the fulcrum O_2,

$F_2 * l = M_N + M_F$

If $M_F > M_N$ the brakes become self locking.

This self locking effect leads the fact of skidding during braking at high speeds, so this is important to improve the value of normal reaction during braking for minimizing skidding.

This is concluded from the *law of lever* concept.

$$F * a = F_1 * b$$

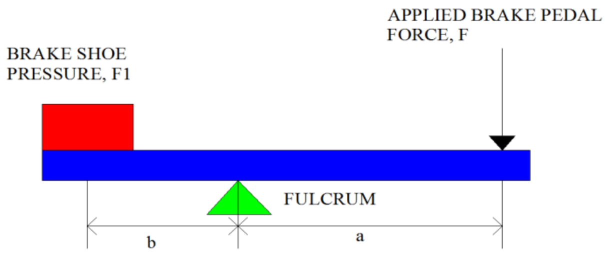


Fig.8.2. Layout of rear brake pedal with shoe

Taking moment balance with respect to the fulcrum point,

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$$F_1 = F * (a / b)$$

Where,

'*F*' is the Input force (force applied on the rear Brake pedal)
'*F*1' is the output force (frictional force developed in brake shoe)
'*a*' is the distance between the input force (brake pedal) and the fulcrum centre.
'b' is the distance between the output force (rear brake shoe) and the fulcrum centre.

The ratio of output to input force is given by the ratio of the perpendicular distances between the lines of action of forces from the fulcrum. This is known as *The Law of lever*.

$$F_1 / F = a / b \text{ (law of lever)}$$
$$b = a * F / F_1$$

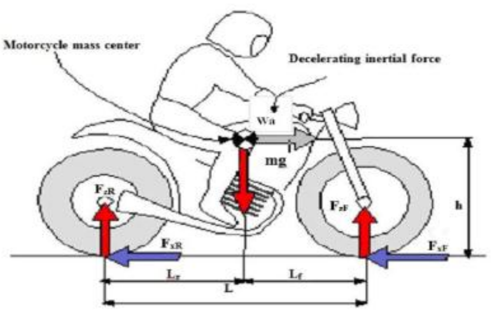

Fig.8.3. Load transfer effect during braking

During the deceleration phase, the load on the front wheel increases while the load on the rear wheel decreases, due to load transfer effect.

Static front axle load,

$$F_{ZF} = mg\,(L_r / L)$$

Static rear axle load,

$$F_{ZR} = mg\,(L_f / L)$$

The dynamic load on the front wheel is equal to the sum of the static load and of the load transfer effect.

$$F_{ZFdyn} = mg\,(L_r / L) + F\,(h / L)$$

While the dynamic load on the rear wheel is equal to the difference between the static load and the load transfer effect.

$$F_{ZRdyn} = mg\,(L_f / L) – F\,(h /L)$$

Where,
F (h / L) is the load transfer effect on the road wheels.

It can be concluded that the dynamic load on front wheel is increased due to the addition of load transfer effect to the front wheel while the dynamic load on the rear wheel is decreased due to the load transfer effect from the rear to the front.

IX. Methodolgy For Incresing The Normal Reaction

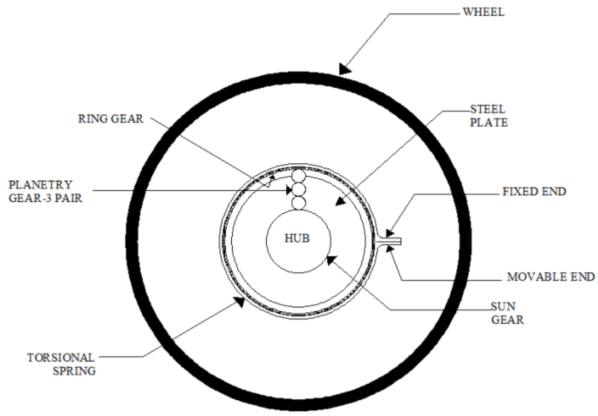

Fig. 9.1. Rear wheel with mechanical arrangement

This methodology consists of the following additional arrangements with the rear wheel.

1. The hub which turns into sun gear
2. A steel plate which is attached with the hub and having able to rotate freely with the wheel rotation.
3. 3 pair of small gears connected with hub and placed along with the surface of the steel plate.
4. A ring gear is attached with most end small gear.
5. And finally a round wire coiled torsional spring placed the circumference of the ring gear can twist when the ring gear rotates.

This the torsional spring a mechanical element after determining the spring load or torque required and end formations, the designer usually estimates suitable space or size limitations.

Torque is a force applied to a moment arm and tends to produce rotation. Torsion springs exert torque in a circular arc and the arms are rotated about the central axis. It should be noted that the stress produced is in bending, not in torsion. When a load is specified at a distance from a centreline, the torque is equal to the load multiplied by the distance.

Here the torsional spring takes main role for increasing normal reaction by means of its deflection. It disturb the wheels rotation while sudden braking at high speeds by means of its elongation from its original position to other. This creates some artificial inertia to rear wheels and the transmission.

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X. Working Of This Method

The following step by step procedure shows the method of this system working.

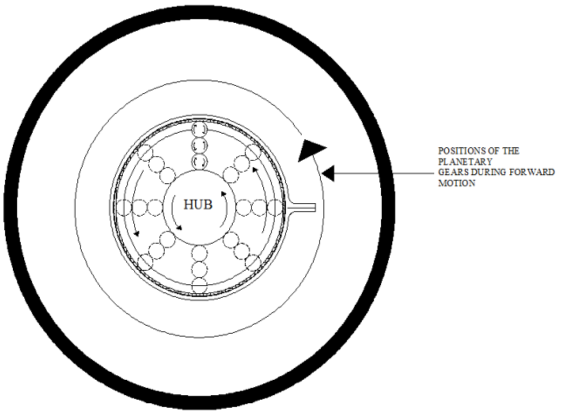

Fig.10.1. Forward motion of the vehicle

During forward motion of the vehicle the steel plate attached with the vehicle's hub also rotates with the hub's direction. The planetary gear attached with the steel plate has also takes rotation with the steel plate. The planetary gears show 360° rotation.

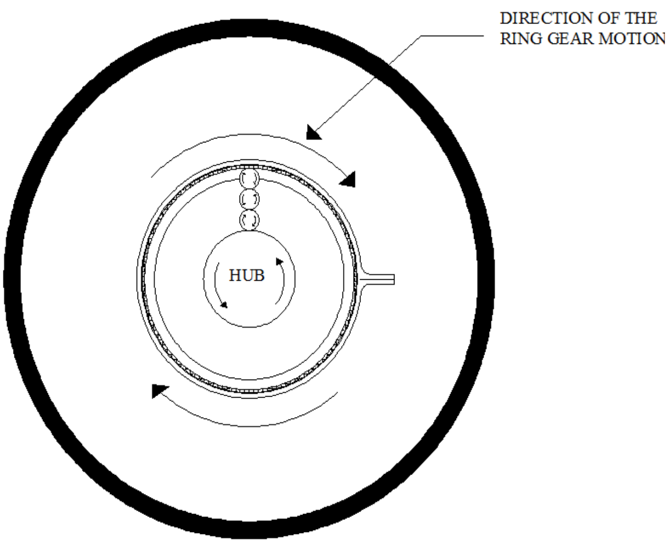

Fig.10.2. During braking of the vehicle

When the driver applying brakes at high speeds, first the steel plate attached with the wheels hub get stopped. So the planetary gear in the steel plate at any position has stopped its 360° rotation, but remains its self rotation. Because of its self rotation, it initiates the ring gear rotation opposite to the vehicles direction.

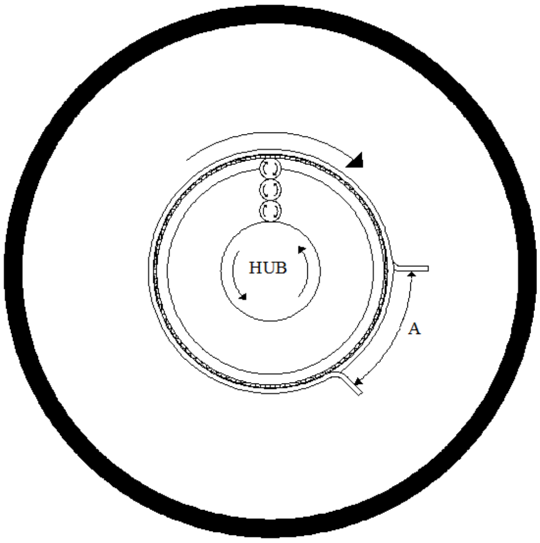

Fig.10.3. Twisting of the spring

When the rotation of the steel plate is restricted, the planetary gears are initiates the ring gear rotation. When the ring gear starts its rotation, the torsional spring attached with the ring gear get twisted. Due to this twist it creates some artificial inertia to the rear wheels by means of gears. So the wheel gets tension, and reduces the vehicle speed then the brakes will able to stop the vehicle at high speeds without skidding. From above diagram the **A** represents the angle of twisting. This works only when the vehicle speed is high, because for twisting the torsional spring we need more torque. For the initial twist we need more torque then the value of the torque reduces simultaneously. So that lot of tension created to the rear wheels hub. Due to this tension the normal reactions of the rear wheel increase. Here the normal force can calculate by using the following relation $N=mg\cos\theta$. Here the value of θ is the position of the planetary gears during braking in the steel plate. The position of those gears can change time to time. If the position of those gears comes to the vertical axis of the rear wheel, there is no need to calculating the value of θ. But it is rare to coincide the gears with that axis.

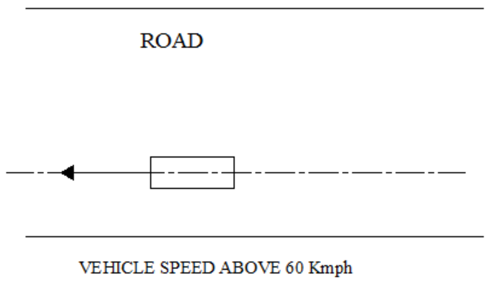

Fig.10.4. forward motion of the vehicle

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Form the above diagram it is clearly known that the vehicle takes its linear velocity along the normal road. Here there is no fluctuation with its line of action.

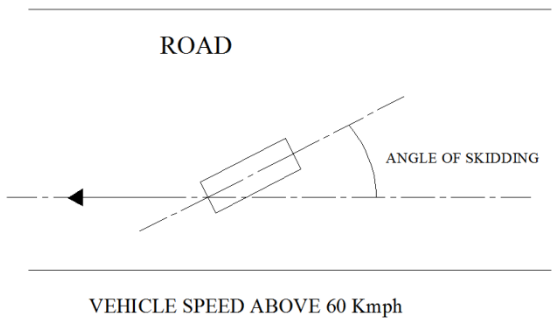

Fig.10.5. during braking at high speeds

Now from the above diagram it is known that, when the vehicle was broke at high speeds it will get some angle of deflection from its line of action. This is known as skidding. How it is happens means the dynamic load of the rear wheels are transferred to the front wheels during braking, so that the normal reaction of the rear wheel decreases. it will leads the fact skidding. The skidding angle increases when the speed of the vehicle increases, and it is also depends on the surface. But it is no matter by using the recovery system with rear brakes when the vehicle takes even slippery surface. Because providing the system with rear wheels brake first the system increases the effect normal reaction through making deflection in torsional spring. So the mass of the rear wheel increases. It is sufficient to provide better braking without any skidding.

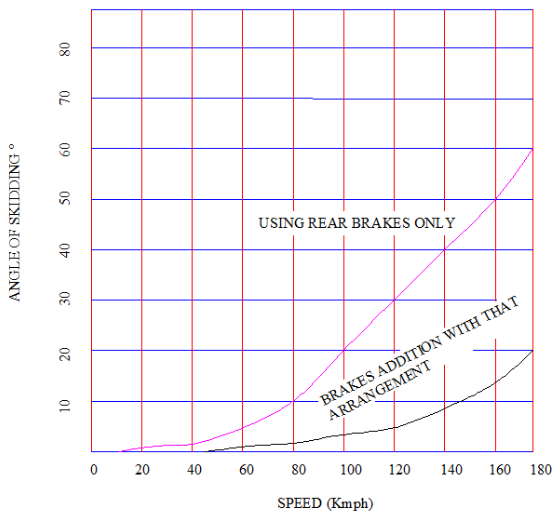

Fig.10.5. Theoretical value of skidding angle with respect to the vehicle speed

XI. Conclusion

By introducing this additional arrangement with the rear wheel brakes we could minimize the fact of skidding during braking at high speeds. The maximum torque required to twist the torsional spring. It is possible when the vehicle speed is high. Although we use this method we can get some skidding while braking. It is obtained because the torque in forward motion uses to twist the spring; here the torque value is low compared with this forward value.

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