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Research Article

VIBRATORY ANALYSIS OF A HERO BRAND MOTORCYCLE ON THE TRAIL OF THE BOYONGA VILLAGE IN THE DEMOCRATIC REPUBLIC OF THE CONGO

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ABSTRACT

The purpose of this note is the search for dynamic behavior and good knowledge of a motorcycle brand "HERO" as a mechanical structure driven by a biker and carrying a passenger by moving on the path from the city of Lubumbashi to the BOYONGA village, behind the factories of CHEMAF site KALUKULUKU. It is a path in poor circulation, where four-wheeled vehicles can not pass properly because of the many characteristic holes accompanied by climbs and descents.
This study concerns the determination of the elementary operations of the movements, in order to release the physical phenomena to the low of the transmission of the vibrations, seats of the discomfort of the motorcyclist and the passenger, sometimes decreasing the driving safety of the motorcycle.
The vibration is defined according to the ISO 2041 standard as a variation in time of the intensity of a characteristic magnitude of movement or the position of a mechanical system, when the intensity is alternatively greater and smaller than a certain average value of reference.
Indeed, a body is said to vibrate motion when it is animated by an oscillatory movement around a position of equilibrium or ofreference.

INTRODUCTION

The interest of this article is justified by the fact that many motorcycle operators have limited knowledge about the optimum and judicious use, the systematic and regular use of their motorcycles. The operating time of these devices and the length of their life depends on them. However, the safeguarding of the security and the performance passes by the preliminary observation of the dynamic conditions and the stability on the ground of evolution of the apparatus.

Indeed, the progressive deterioration of the good functioning of the system reduces the performances of the mechanisms, thus generating various vibrations.

These mechanical vibrations are often very troublesome for the man and the machine itself. Under certain conditions, a vibratory movement can generate very large dynamic forces and excessive resulting deformations, which can lead to a premature shutdown of the machine hich could result for example from fatigue failure, wear or any other physical phenomenon.

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Techniques and experimental procedures

Motorcycle

Definition

A motorcycle, more commonly referred to as its "motorcycle" apocope, is a motorized vehicle, without a bodywork, with two wheels most often single-tracked.

Positioning

Sitting on a saddle astride, the helmeted driver holds in his hands a handlebar. His feet are on the ground when he is stopped, and on footrests when the vehicle is moving; The rear seat can accommodate a passenger or merchandise.

Evolution

The fatherhood of the invention of the motorcycle returns to Louis-Guillaume Perreaux, Engineer in Paris. He filed his patent December 23, 1868. His vehicle is a velocipede equipped with a steam engine that drives the rear wheel.
Both pedals act on the front wheel.

In 1885, Daimler tested the installation of a petrol engine.
Ten years later, the Werner brothers market their version equipped with a motor placed above the front wheel.

Use

The motorcycle knows today declensions for a daily use, sports, tourist road or any way. The chassis differ according to the constraints that the machine will undergo. Each organ is thought to agree with the center of gravity. The suspensions require rigorous adjustments because a loss of adhesion can lead to a loss of control. Disc and drum brakes help braking.

Learning and mastering the counter-braking, gyroscopic precession of the front wheel, the trajectories, driving the look and anticipation, the dead angle of the motorists, braking, are essential steps to limit the risk of accident.

Introduction

Photo of a " HERO " motorcycle

Importance

In the early days, the motorcycle was very unreliable. It required frequent mechanical interventions. In addition, the roads were in poor condition and suspensions were non-existent (if the springs of the saddle are not taken into account). But soon the use of the motorcycle was spread by starting to be a tool of work of the liberal professions.

The first world war favored its use for military purposes.
Around 1968, the motorcycle, because of gentrification and to compete with the automobile, became a distinctive means of transport of freedom and economy of fuel consumption.
It is used as a utility or as a public transport that accepts a passenger and a large luggage.
In major cities, it avoids the many traffic jams, but also the difficulties of parking in the city center.

Technical constraints

The construction of motorcycles is special. The chassis are designed according to the use of the machine and the constraints to undergo. Each organ must find its place according to different criteria like the center of gravity. The various suspension models require good adjustments because the slightest loss of grip can lead to loss of control of the bike. They have evolved over time. Disc or drum brakes are used with recently introduced brake aids.

Motor side, in addition to the electric motor, there are single-cylinder engines, cylindrical tri-cylindrical, quadri cylindrical ... etc.

Nowadays the motorcycle is a motor cycle of several displacements. The bikes are classified according to their power and their capacity.

The HERO motorcycle is of the road type designed for long journeys. It is a single cylinder with a cylinder capacity of 1250 cm^3. It favors driving comfort. This type is characterized by a driving position close to the vertical to keep the back straight, arms extended and legs unfolded.

The transmission is composed of a set of elements: clutch, gearbox, chain, wheel. The tank of twelve liters of gasoline allows a range of about 360 kilometers. His maximum speed is up to 120 kilometers per hour on his bard board. The motive power is 20 kilowatts. The featherweight of its chassis is 125 kilograms, the total weight is 180 kilograms, the purchase cost in Lubumbashi is plus or minus thousand US dollars.

Security and Accidentology

Many people think that motorcycle accidents are due to an excessive risk-taking or excessive speed of bikers. However, according to the MAIDS study by the Association of European Motorcycle Manufacturers (ACEM), the speed of movement of the motorcycle at the moment of impact is less than 50 km / h in 70% of cases and the majority of accidents studied occurred in urban areas. Speeding contributes to the accident only in a few isolated cases.

Moreover a technical phenomenon is involved in less than 1% of cases, mainly because of tires.

In more than 50% of cases, the first cause of the accident is human error on the part of a third-party vehicle and not the motorcycle. Among the main causes of accidents, drivers of other vehicles who have made a human error "did not detect" the presence of the motorcycle in more than 70% of cases, especially if the driver only has the car license . Among bikers, young drivers between the ages of 18 and 25 are overrepresented in crashes, when the 41-55 age group was under-represented showing that drivers in this age group have a lower risk of accidents. Road infrastructures are designed primarily for cars, they rarely take into account the characteristics of motorcycle driving, for which they can be dangerous: risk of serious injury to the lower limbs, spine or head from where the port helmets.

Cycle Dynamics

General

The dynamics of cycles is the science of the movement of bicycles and motorcycles and the elements that compose them, caused by the forces they undergo.

Dynamics is a branch of classical mechanics, itself part of physics. Bicycles and motorcycles are both single-path vehicles, which makes the characteristics of their movement fundamentally similar.

The simplified modeling of a motorcycle is a bike. His movements that are of interest are the swinging, the direction, the braking, the use of the suspension and the vibration. Experiments and analyzes have shown that a bicycle was standing when it was steered to maintain its center of gravity above the wheels. This direction is usually done by a cyclist or under certain circumstances of the bike itself. The long-standing idea that the gyroscopic effect is the main stabilizing force of the bicycle has been refuted. While keeping straight up may be the primary goal of the beginner, a bike must bow to maintain balance in a turn: The higher the speed, or the lower the angle of turn, the more it must bow . This makes it possible to overcome the centrifugal force of the turn by the force of gravity due to the inclination. During braking, depending on the location of the joint center of gravity of the bicycle and the rider with respect to the point of contact between the front wheel and the ground, the front wheel may slip, or the bicycle and cyclist may pass through. above the front wheel.

Analysis of the behavior of the cycles

Forces

If we consider the motorcycle and the rider as a single system, the forces acting on this system can be classified into two categories:

- External forces: due to gravity, inertia, contact with the ground and in contact with the atmosphere.
- Internal forces: caused by the rider and his interaction with the elements of the bike.

External forces: all masses, the rider and all elements of the motorcycle are attracted to the ground by gravity. Gravitational pull is neglected between the elements themselves with regard to all the forces involved at the point of contact with the ground. There are ground reaction forces that have a horizontal component and a vertical component.

- The vertical component counterbalances essentially the gravitational force, but also varies with braking and acceleration.
- The horizontal component is due to the friction between the wheels and the ground and includes resistance to rotation. It is a reaction to the forces of propulsion, braking and turning. Turning forces are caused by maneuvers to balance the bike in addition to the simple change of direction.

They can be interpreted as centrifugal forces in the frame of acceleration of the motorcycle and the biker or simply as an inertia in a stationary Galilean frame of reference and not as forces.

The gyroscopic forces that act on the rotating parts like the wheels, the transmission are also due to the inertia of these elements. The aerodynamic forces due to the atmosphere are essentially the drag forces, but can also take the form of side winds.

Internal forces: compared to the system, those caused mainly by the biker and the friction. The biker can print couples between the steering mechanism (front fork, handlebars, front wheel) and the frame. Forces of friction occur between all the parts of the bike that are moving one against the other: in the hubs, in the transmission, between the mechanism of direction and setting, etc. The bikes have front and rear suspensions and sometimes a steering damper to dispel any form of unwanted energy.

Equilibrium

A motorcycle stays upright when it is steered so that the forces of reaction of the soil compensates for exactly all the other forces it undergoes: gravity, centrifugal force when cornering and aerodynamic forces in case of blast of hand ... etc. Management may be a rider or under certain circumstances of the bike itself. This self-equilibrium is then caused by the combination of several effects that depend on the geometry, the weight distribution and the speed of advancement of the motorcycle.

However tires, suspension, steering damping and flexibilityframe can also influence this phenomenon. If the direction of a motorcycle is blocked, it becomes almost impossible to preserve its balance during the conduct.

Speed

The rider transmits torque to the handlebars to turn the front wheel, which helps control the tilt and maintain balance.At a high speed, even a weak steering angle causes a rapid lateral displacement of the ground contact points; at a slower speed, use larger direction angles to achieve the same effect as quickly.

Location of the center of gravity

The more the combined center of gravity of the motorcycle and rider is at the front (close to the front wheel), the less the wheel must move laterally to maintain balance. Conversely, the more the center of gravity is at the rear (close to the rear wheel), the more lateral movement of the front wheel must be important to preserve the equilibrium of the motorcycle.

This phenomenon is particularly noticeable on road motorcycles that carry a large load above or even behind the rear wheel.

It is advisable to carry the low load on a motorcycle, especially in leaving the bags hanging on both sides of the luggage rack.

Hunt

The hunt is another factor that influences the bike's handling. It's aboutthe distance between the contact of the front wheel with the ground and the intersection of the ground and the axis of direction which is the axisaround which the entire steering mechanism pivots (fork, handlebars, front wheel).

The hunt set back from the vertical makes the wheel spin forward in the direction in which the motorcycle leans, regardless of his speed.

The more hunting there is, the more stability there is.
Negative hunting creates instability even when driving is possible.
A hunt too important makes it difficult to transfer the bike. A hunt between 23.5 mm and 37 mm is suitable.

Weight distribution of the steering mechanism

The distribution of the mass in the steering mechanism (front wheel, fork and handlebar) contributes to the balance of the motorcycle. If the center of gravity of the steering mechanism is before the steering axis, the force of gravity rotates the wheel in the direction in which the motorcycle leans. Note also that the position of front and rear of the center of gravity or its height also contributes to the dynamic behavior of the bike.

Gyroscopic effects

The gyroscopic effect on the front wheel of a motorcycle, the application of a torque C_1 to the axis 1 of inclination ε causes a reaction torque C_2 applied to the steering axis 2. The role of the Gyroscopic effect is to help turn the front wheel in the tilt direction. This phenomenon is called Precession, its magnitude is inversely proportional to the speed of rotation of the object.

Less front wheel turns faster, more precession is important and vice versa. Unlike the front wheel, the rear wheel is not subject to this phenomenon because of the friction of the tires on the ground: so she switches in the same way as if she was at shutdown. So the gyroscopic effect does not prevent the failover.

At low speed, the precession of the front wheel is very strong; which has the effect of rendering the motorcycle uncontrollable with a tendency to turn very strong (one kind of oversteer) to lean over the other side, which can cause oscillations and therefore a fall. At high speed, conversely, the precession is weak, this makes the motorcycle hardly maneuverable. It tends to " refute " the turn. The weather characteristic of this instability is long, of the order of a few seconds. What does makes it easy to counter. So a motorcycle that goes fast may seem stable even if it is not in reality and becomes unstable if not controlled.

Another contribution of gyroscopic effects is the creation of a moment (of roll) by the front wheel during a counter steering. This allows the pilot to launch a turn quickly. For example for a left turn, the pilot starts first turn right. This has the effect of tilting the machine to the left and helping the pilot to engage his turn.

Principal dynamic constituents of a motorcycle

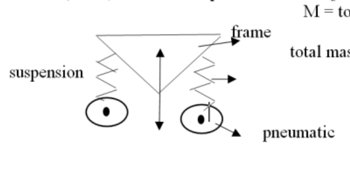
The tire and the suspension are the main dynamic components of the entire motorcycle. The tire is a low frequency suspension element (less than 10 Hz). The multifrequency excitation generated by the profile and the quality of the path to the MBOYONGA village in question here is first filtered by the transfer function related to the stiffness and damping characteristics of the tire.However the mass that the dynamic components suspend (the weight of the motorcycle: 180 kg, the rider: average 60 kg and his passenger: average 60 kg) is responsible, all things being equal, of the big energy production on a frequency band as narrow as the internal damping of the tire is low.

Note that the frequency of a tire is between 1 and 4 Hz for a viscous damping close to 5%.

Dynamic modeling (Fig. 1) with a "2-point" suspension of the motorcycle (Fig. 2) characterizes the vibratory mode called " pumping mode " whose eigenfrequency is calculated by the formula:

(in Hz) with: K = suspension stiffness [N / m]

M = total mass (machine + rider + passenger)



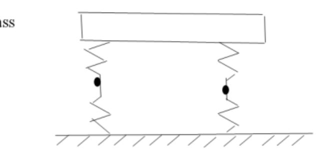
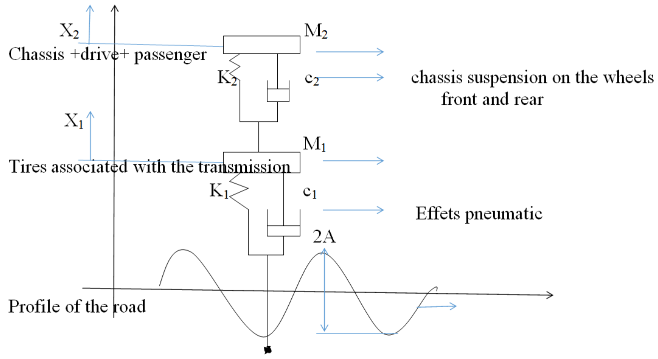


Fig 1 dynamic modeling For a motorcycle

Fig 2: suspension at " 2 point "

During a traffic on such a path with irregularities idealized bysinusoidal evolution, the motorcycle HERO whose tires are about 132 cm apart between axes, we found that if the front wheel falls into a considerable hole a dozen centimeters, the head of the rider will feel a weight effect acceleration down quite important. At the passage of the rear wheel in the same hole, there is a sudden rise of the rider's head with an opposite effect.In addition to these phenomena, the frequency range of the excitation caused by the effect of the path to the sinusoidal profile is wide and starts very low. Indeed, under certain conditions (slow speeds, multiple holes, abrupt descents) the excitation can be centered on a line between 1 and 2 Hz. This is the excitation frequency fexcit.

Simplified approach of the dynamic model



The dynamic model of the motorcycle is a simplified approach to two stages (fig.3) whose mathematical model is only one degree of freedom and comprising mass - viscous damping spring. The first floor symbolizes the pneumatic part associated with the transmission of power. The second stage models the chassis suspension on the front wheels and back.

i_1. Calculation of viscous damping 1st stage

M1 = mass (motorcycle-rider-passenger)
= 180 kg + 60 kg + 60 kg
= 300 kg
= 3,000 N

With K1 = stiffness of the tire (tires of the motorcycle): $2.1318{,}10^{6}$ N / m

The natural frequency of the 1st floor: $f_1 = \dfrac{1}{2\pi}\sqrt{\dfrac{K_1}{M_1}}$

$$f_1 = \frac{1}{2{,}3.14}\sqrt{\frac{2.1318{,}10^{6}}{3000}} = 2.244 \text{ Hz}$$

The critical damping of the 1st floor: Ccrit1 $= 2\sqrt{K_1 M_1}$

Ccrit1 $= 2\sqrt{2.1318{,}10^{6}{,}3000}$
= 159,942.48 Ns / m

The pneumatic damping being C_1 = 12,000 Ns / m

We have the viscous damping coefficient:

$$\varepsilon_1 = \frac{c_1}{Ccrit_1} = \frac{12000}{159942{,}48} = 0.075 \text{ soit } 7.5\% \text{ (low)}$$

I_2. Calculation of viscous damping 2nd stage

M2 = mass (chassis-rider-passenger)
= 100 kg + 60 kg + 60 kg
= 220 kg
= 2 200 N

With K2: stiffness of the suspension (shock absorber of the motorcycle) = 1, 1052.105 N / m

The natural frequency of the 2nd floor: $f_2 = \dfrac{1}{2\pi}\sqrt{\dfrac{K_2}{M_2}}$

$$f_2 = \frac{1}{2{,}3.14}\sqrt{\frac{1.1053{,}10^5}{2200}} =$$

1.128 Hz

Knowing that the damping of the suspension C_2 = 21,000 N / ms^{-1}

The coefficient of viscous damping of the 2nd stage:

$$\varepsilon_2 = \frac{c_2}{Ccrit_2} = \frac{c_2}{2\sqrt{K_2.M_2}} = \frac{21000}{2\sqrt{1.1053{,}10^5{,}2200}}$$

= = 0.632 or 63.2% (critical)

Let us note that all the temporal accelerations of these stages influencing the system; we must verify that:

$f_{excit} > \sqrt{2} f_p$ with f_p : natural frequency of the system.

Since the excitatory frequency of the profile of a trail of this kind is about 2 Hz, and that the natural frequency of the system is the most small whose coefficient of viscous damping the most critical we say that ε_2 is imposed by f_p = f_2 = 1.128 Hz

We then have $\sqrt{2} f_2 = \sqrt{2}{,}1.128$ = 1.5952 Hz

Note that 2 Hz> 1.5952Hz; so the effort transmitted is less than the disruptive effort. The system then works in the area attenuation or vibration isolation.

In this area:

- The attenuation is even stronger than the damping is weak.
- The attenuation is even stronger than the frequency ratio is large (we move away from the resonance).

All in all, this motorcycle is protected from harmful vibrations, even on country trails due to good vibration isolation due to its suspension system and its tire.

However, the maintenance of the system must be in order to guarantee the service life under the same operating conditions. A new motorcycle in perfect working order will produce very little vibration. Without proper maintenance, the deterioration of operation usually leads to an increase in the level of vibrations.

By observing the evolution of this level of vibration, it is therefore possible to obtain information on the state of the machine.

These vibrations occupy a privileged place among the parameters to be taken into consideration when making a diagnosis.

CONCLUSION

This scientific work provides an overview of the proper use of the HERO motorcycle, a brand popular in rural transport around the city of Lubumbashi.

Negative vibrations due to the condition of country roads with many irregularities, contribute to the acceleration of the early decommissioning of motorcycles if there is no preventive maintenance policy.

Previous calculations have shown that despite the holes in which the device moves, the transmitted force was less than the disturbing force so that the system guarantees work in the vibration isolation zone.

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