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ARTICLE

The Simulation on Dynamic of Rotary Inertia and Engine's Inflamer in Light Vehicle

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ABSTRACT

According to formula we can simulate their driven force and acceleration. The mechanical formula is used to obtain dynamics is used to simulate. The driven force increases when torque increases and tire diameter decreases. We need torque to increase so this is our plan. Acceleration raises when torque raises and it reduces when its weight raises. With the decreasing of radius of road the centripetal acceleration is increasing in the condition of light vehicle. It is that it decreases sluggishly before 0.35m/s2 then it maintains a steep decline to 0.62m/s2 and at last becomes sluggish again. It is valued that the economical efficiency about consumed fuel under different power. In the time of 0.2hr the fuel inflamer inclines sharply first then turns stable. It is the smallest value. Beyond it the fuel maintains a high value all the time. The discharged pollution gas decreases with the decreasing initial temperature. The low initial temperature is good to fuel gas. Meantime the smallest incline range is 300~350K which explains that it is the most save one.

1. Introduction

The power transmission of an vehicle is driven by torque, which is generated by the engine.Therefore, the measurement of torque is the evaluation of the vehicle power system, has an important role.[1,2] this paper studies the overall performance of the vehicle, including whether the braking performance of the vehicle achieves the best performance, through the torque, power and revolution of the vehicle engine.The kinematics of the vehicle takes speed and acceleration as research parameters and acceleration and braking as the main purpose of design.Therefore, the organic combination of power and movement is the real purpose of evaluating the car. Audi's 3.0t engine has a maximum power of 333ps, while Mercedes-benz's A45 AMG has a 2.0t engine of 360ps.With the increase of horsepower, their dynamic analysis and kinematics become particularly important. Such as torque and acceleration analysis. The horsepower of a truck is the most important factor. It is the main condition that designers should expect in advance that they can finish the task without environmental contamination. The car's load and less inflamer is the embodiment of its design level ability. The acceleration of the car is the main performance of the

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car, the acceleration is directly reflected in its function. A good engine function will be achieved in a relatively short time. Therefore, this paper explores whether the data of vehicle design are feasible based on the high power and acceleration of the vehicle, and discusses the status of high power and high torque to meet the needs of future vehicle development. Meantime the engine's inflamer properties is also proposed. [3,4]

2. Calculation Results and Discussion

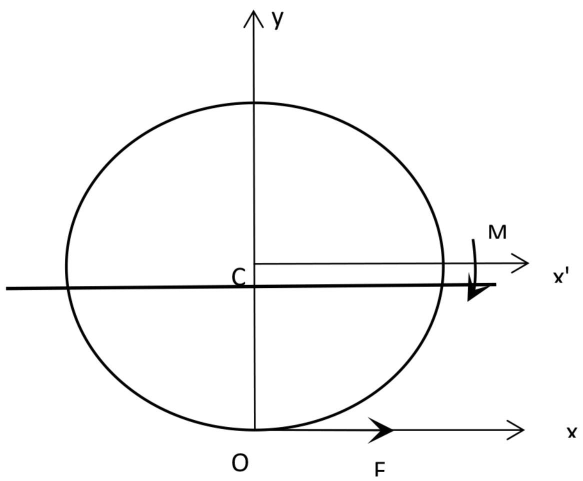

Figure 1. The relation of torque and Force on tire in car

Figure 1 shows the situation of vehicle tire subjected to torque and force.

From Newton's second law

$$F = ma \quad (1)$$

A is the tire acceleration, F is the force, and m is the mass.If C is the center of mass of the tire, R is the radius of the tire, and Mc is the torque of C.

2.1 Curve of Acceleration and Driving Force

2.1.1 Definition of Velocity

Because the moment of inertia of the wheel.

$$J_C = mR^2 / 2 \quad (2)$$

Here m is the mass of the car;A is acceleration.

In the reference frame with the center of mass at point C as the origin, the moment of motion of the particle system to point C refers to its moment of motion at this point in absolute motion

$$L_c = \sum M_c(m_i v_i) = \sum R_i * m_i v_i \quad (3)$$

If I take mi as the moving point x 'y' and z' as the moving point, I have

$$v_i = v_c + v_{i'} \quad (4)$$

Substitute into equation (3)

$$L_c = \sum m_i R_i' * (v_c + v_{i'}) = \sum m_i R_i' * v_c + \sum m_i R_i' * v_{i'} \quad (5)$$

Due to the $\sum m_i R_i' = \sum m_i R_c' = 0$

So $L_c = \sum M_c(m_i v_{i'}) = \sum R_i' * m_i v_{i'}$ (6).

The moment of force of a particle system on C is the same as the moment of force of a particle system calculated at its relative velocity or its absolute velocity.

And the same thing applies to the moment at fixed point O

$$L_o = \sum M_o(m_i v_i) = \sum R_i' * m_i v_i \quad (7)$$

So the radius is R, and the absolute velocity is vi

The torque of the wheel at O

$$M_o = J_c \omega = mR^2 / 2 * \omega \quad (9)$$

2.1.2 Formula of Driving Force

The external force acting on the wheel can be simplified into plane force system F1, F2..., Fn uses the motion theorem of point C and the torque theorem of relative point C

$$ma = \sum F \quad (10)$$

Because angular acceleration $a = \frac{d\omega}{dt}$

$$\frac{d}{dt}(J_c \omega) = J_c \alpha = \sum M_c(F) \quad (11)$$

It can be converted into

$$m \frac{d^2 R}{dt^2} = \sum F \quad (12).$$

And

$$J_c \frac{d^2 \varphi}{dt^2} = \sum M_c(F) \quad (13)$$

Because O is the origin of the original coordinate, and C is the origin of the new coordinate.

Let M be the moment, and let the moment of rotation be

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$$M_c = M_0 - M_c^{'} \tag{14}$$

Since $M_0 = (mR^2/2)\cdot\alpha$ (15)

Parallel-motion coordinate system

$$M_c^{'} = FR \tag{16}$$

$$M_c = (mR^2/2)\cdot\alpha + FR \tag{17}$$

Because $a = R\alpha$ (18)

So $M_c = (mR^2/2)\cdot\alpha + FR$ (19)

Because $M_c^{'} = M$ (20)

So $M = FR + (mR^2/2)\cdot a/R$ (21)

Calculated and substitute below (31) to

$$a = 2M/3mR = \frac{2*9.554*P/n}{3mR} \tag{22}$$

Substitute (21) into the above equation to get

$$F = \frac{2M}{3R} = \frac{2*9.554*P/n}{3R} \tag{23}$$

2.1.2 Formula of Angular Acceleration

Figure 2 is the vehicle state of turn. R1is the radius of road; Mc is driven torque; Fc is centripetal force; R is the radius of tire.

The external force acting on the wheel can be simplified into plane force system F1, F2..., Fn uses the motion theorem of point C and the torque theorem of relative point C

$$ma = \sum F \tag{24}$$

Because angular acceleration $a = \frac{d\omega}{dt}$

$$\frac{d}{dt}(J_c\omega) = J_c\alpha = \sum M_c(F) \tag{25}$$

It can be converted into

$$m\frac{d^2R}{dt^2} = \sum F \tag{26}$$

And

$$J_c\frac{d^2\varphi}{dt^2} = \sum M_c(F) \tag{27}$$

Because O is the origin of the original coordinate, and C is the origin of the new coordinate.

Let M be the moment, and let the moment of rotation be

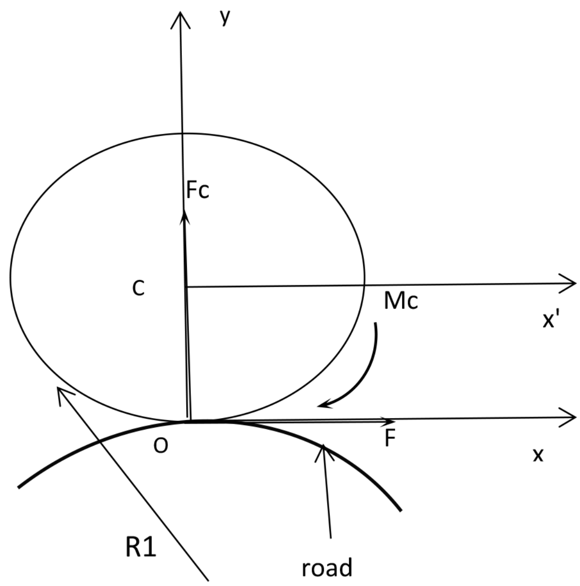

Figure 2. The vehicle state of turn. R1is the radius of road; Mc is driven torque; Fc is centripetal force; R is the radius of tire

$$M_c = M_0 - M_c^{'} \tag{28}$$

Since $M_0 = (mR^2/2)\cdot\alpha$ (29)

Parallel-motion coordinate system

$$M_c^{'} = FR \tag{30}$$

$$M_c = (mR^2/2)\cdot\alpha + FR \tag{31}$$

Because $a = R\alpha$ (32)

So $M_c = (mR^2/2)\cdot\alpha + FR$ (33)

Because $M_c^{'} = M$ (34)

So $M = FR + (mR^2/2)\cdot a/R$ (35)

Calculated and substitute below (33) to

$FR = M - (mR^2 / 2) \cdot a / R$ is $F = M / R - \frac{mRa}{2}$ (36)

Because $F = Ma$ (37)

And $F = \frac{mv^2}{R_1} = ma_\tau$ (38)

Because $v = v_0 + at$ (39)

Substitute (38) to (39) is

$F = \frac{m(v_0 + at)^2}{R_1} = ma$ (40) gains

$(v_0 + a_\tau t)^2 / a_\tau < R_1$ (41) is

$a_\tau t^2 < R_1$ is

$a_\tau < R_1 / t^2$

$$a_\tau = 2M / 3mR = \frac{2*9.554*P/n}{3mR} \quad (42)$$

Substitute (37) into the above equation to get

$$F = \frac{2M}{3R} = \frac{2*9.554*P/n}{3R} \quad (43)$$

3. Discussion

3.1 Vehicle Driving Force and Acceleration Dynamics

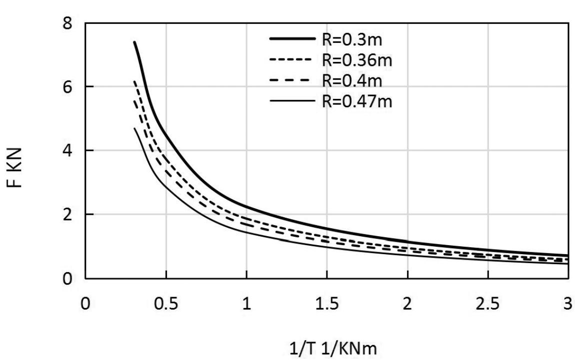

Figure 3. The relation of torque and force at 208KW of engine if R=0.3~0.4m in car

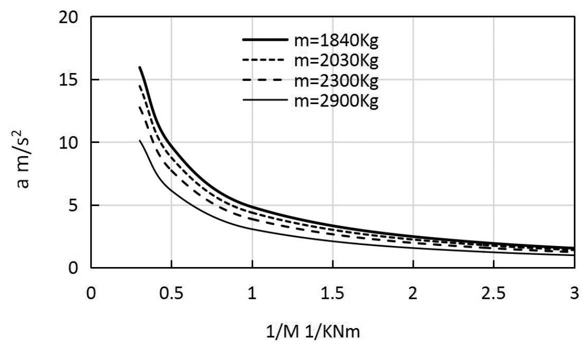

Figure 4. The relation of acceleration and torque if mass=1840~2900Kg in car under condition of 208KW

Figure 3 shows the curves of vehicle torque and force when tire radius R is 0.3~0.47 meters. At this time, the engine power is set at 208KW.As the tire diameter decreases the torque increases, so does the driving force.When the torque is 5KNm, the force reaches 10KN.

As shown in Figure 4 is curve of car acceleration a and torque M when the weight of car m=1840~290Kg and Power is 208KW, here use 208KW. When torque is 5KNmthe acceleration is 5m/s^2. In Figure 4, when tire weight m=1840~290Kg, the curve between acceleration a and torque m of the car is selected as 208KW.As the mass of the car decreases and the acceleration increases, the torque increases and the acceleration increases, they are proportional.Therefore, when designing a car, it is necessary to choose lighter materials or reduce the amount of structure to reduce the weight, so as to increase the acceleration quickly.Increase speed in a very short time.

The curves of the torque and force of the car are shown in Figure 3. When the radius of the car tire is 0.3~0.4m, the forward force between the tire and the ground increases with the increase of the torque, and they form a straight line.The tire radius increases and the forward force decreases, which is why the torque constant force decreases. The difference between them is 2~3KN at 15KNm.Therefore, the tire radius should not be too large when designing a car.

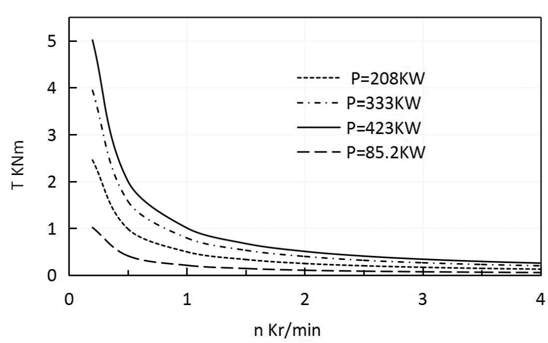

Figure 5. the relation of torque and rotary when P=85.2KW, 208KW, 333KW, 423KW in car

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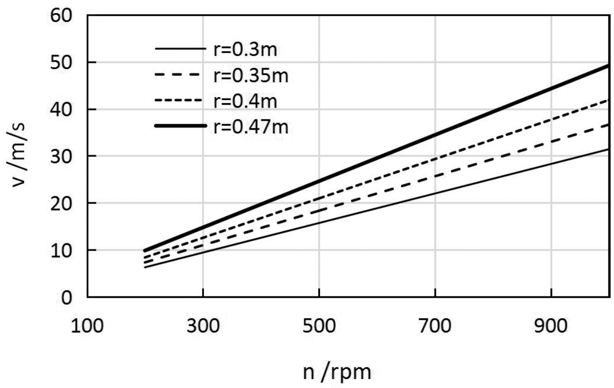

Figure 6. The relation of v and n in vehicle. N is the velocity. R is tire radius

Figure 5 shows the relationship between torque and power of an vehicle and the number of revolutions.The greater the power, the greater the torque.When the power P= 85.2kw ~423KW is 333KW, the torque increases to about 8KNm when the number of revolutions is less than 500rpm.As the number of revolutions increases, the torque decreases, and it remains at 2-3knm under various power conditions above 2000rpm.This means that the faster the car goes, the lower and closer the torque will be to the limit.When the power is 423KW and the speed is lower than 500r/min, the torque reaches 20KNm.When the power is 85.2kw, the torque reaches 4KNm.Considering the passenger or cargo capacity need not be too low, if 1-5 people in the car, there are some goods, then add 100-275kg of power. Figure 6 shows that v will increase when n increases in proportion. Meantime v will decrease when the R increases.

3.2 Vehicle Driving Force and Acceleration Dynamics

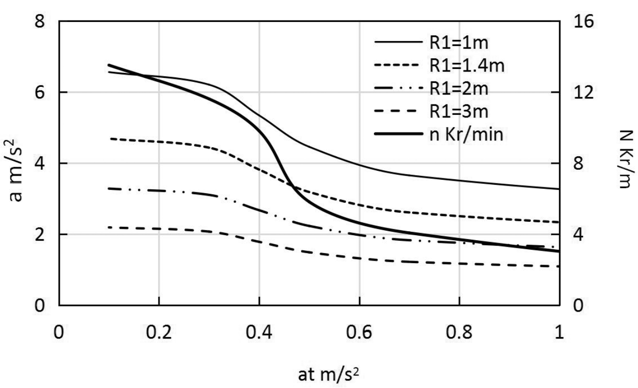

Figure 7. the relation of centripetal and circular acceleration in vehicle under condition of 85.4KW. N is the velocity. R1 is radius of load.

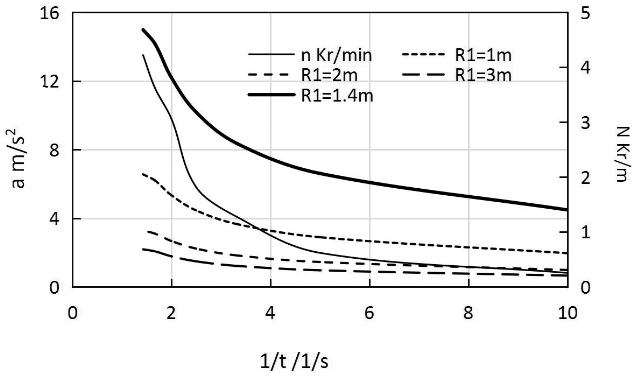

Figure 8. The relation of centripetal acceleration and 1/t in vehicle under condition of 85.4KW. N is the velocity. R1 is radius of load

As shown in Figure 7 the rpm is n and it is be left Y-axis ie.vertical coordinate the right axis is at circular acceleration while x-axis is centripetal acceleration. with the increasing of radius of road the at is decreasing in the condition of 85.4KW and 1.84ton of vehicle. Meantime with the increasing circular acceleration at the centripetal acceleration a is decreasing sluggishly before 0.35m/s^2 then it maintains a steep decline to 0.62m/s^2 and then becomes sluggish again. With the increasing of acceleration a the rpm is decreasing. It is due to inverse relation between n and a in terms of formula (42). The inverse relation of at and a is needed to study further to clarify the phenomenon. Why are they a parabola with increasing function there are negative curve here? We anticipate that the further investigation to do for it. As shown in Figure 8 the relation of acceleration and inverse time has been curved. The a will decrease with inverse time increasing. At the 41/s the at will be steep low and then it becomes softly low. With the increasing road curve radius from 1m to 5m a will decrease meantime. It fits to formula well. For the sake of improving a the small radius will be available and better. The relation of n and 1/t shows in here with the blue curve.

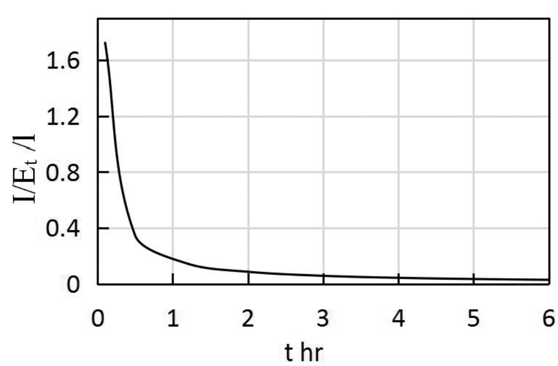

Figure 9. The relation of consumed fuel and time(hr) in engine of vehicle

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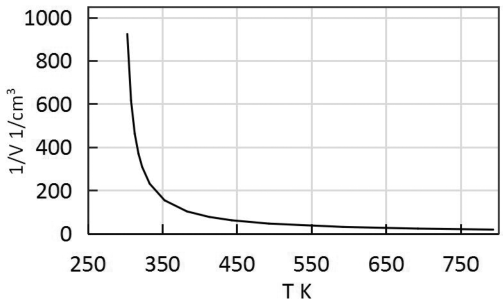

Figure 10. The relation of discharged pollution gas and temperature (K) in engine of vehicle

In Figure 9 it is observed that the consumed fuel $1/E_t$ is inverse proportional to time with the constant of 5.8l/100Km. When the time is 0.1 to 0.9 hours the $1/E_t$ is 59 ie. the consumed Fuel is from 0.016 to 0.125 liter respectively. In the time of 0.2 hr the curve gently declines. It indicates that the fuel inclines sharply first then turns stably. In Figure 10 it is found that the discharged pollution gas increases with the increasing initial temperature. Meantime the big steep range is 300~350K ie. 27~77℃ . this explains that the steep rate of them is low.

4. Conclusion

(1) The greater the power, the greater the torque. As the number of revolutions increases, the torque decreases, and it remains at 2-3KNm under various power above 2000rpm. When the torque is 5KNm, the force reaches 10KN. As the mass of the car decreases and the acceleration increases, so does the torque and the acceleration. This is a destination for us to improve car properties. Therefore, when designing a car, it is necessary to choose lighter materials or reduce the amount of structure due to its weight so as to increase the acceleration quickly.

(2) With the increasing circular acceleration the centripetal acceleration is decreasing sluggishly before $0.35m/s^2$ then it maintains a steep decline to $0.62m/s^2$ and then becomes sluggish again. With the increasing of acceleration the rpm is decreasing. It is due to inverse relation between rotation and acceleration.

(3) In the time of 0.2 hr the curve gently declines. It indicates that the fuel inclines sharply first then turns stable. The discharged pollution gas increases with the increasing initial temperature. Meantime the big steep range is 300~350K ie. 27~77℃ . this explains that the steep rate of them is low.

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