

THE AUTOMOTIVE PRFORMANCE

I) RESISTANCES:

It's the forces which opposing the vehicle motion ,its value depend mainly on the car size and shape also on and the types of the tire and the road.

Its mainly of (3) types

- 1.The air resistance (R_a)
2. The gradient resistance (R_g)
- 3.The rolling resistance (R_r)

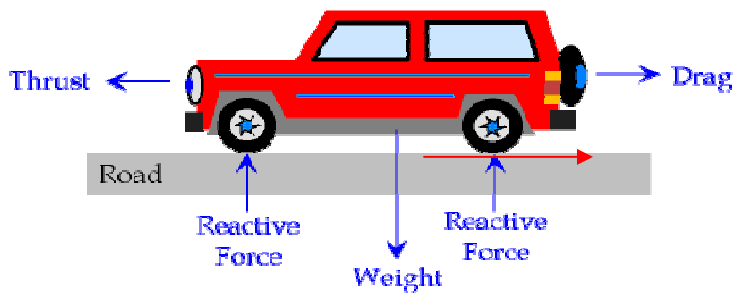


Fig (1) diagram showing all forces acting on the car .

Shape and flow	Form drag	Skin friction
	0%	100%
	~10%	~90%
	~90%	~10%
	100%	0%

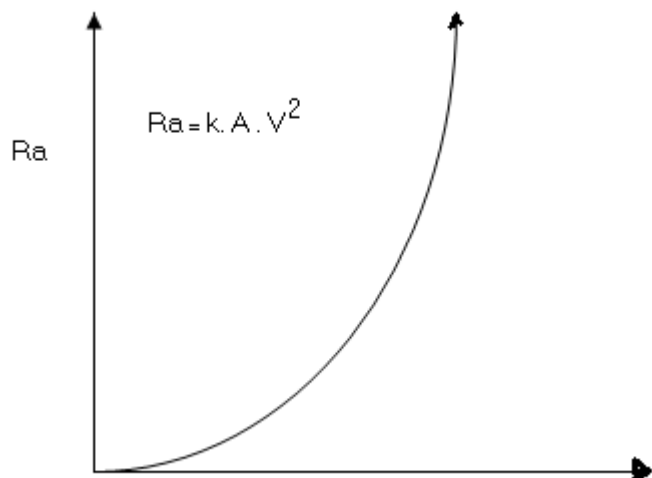


Fig (2) The relationship between the air resistance and the car speed

1. The air resistance (R_a)

As shown in Fig (2) The air opposing the car motion , the value of this resistance is depend mainly on the car shape and speed

.it can be calculated from the following equation

$$R_a = K * A * V^2$$

Where

K – the coefficient of air resistance (<1) ((shape factor))

V – The car speed (m/s)

A-The car frontal area

$$A=0.8 d * h$$

Where

d - the car width (m) h – the car height (m)

EXAMPLE(1)

Calculate the air resistance for a car with $3m^2$ frontal area and a coefficient of air resistance of 0.04. The car was moving by a speed of 85km/hr

2. The Gradient resistance (R_g)

It's the force which prevent the car from moving when the car tend to climb on a gradient road . The gradient resistance (R_g) can be calculated from the following equation

$$R_g = W \sin\alpha$$

Or

$$R_g = W (h/L)$$

$$W = m * g$$

Where

m- the car mass (kg or ton) (1 ton = 1000kg)

g – the car gravitational ($g = 9.81m/s^2$)

h/L and α - The gradient ratio or angle

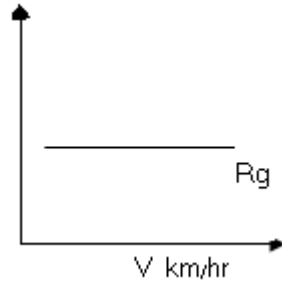


Fig (3) The relationship between the gradient resistance and the car speed

EXAMPLE(2)

Calculate the gradient resistance for a car of 2500 kg mass moving up a road of 3.1% gradient

EXAMPLE(3)

Calculate the gradient resistance for a car of (6)ton kg mass moving up a road of (3°)gradient

3. The Rolling resistance (R_r)

The rolling resistance is caused due to the friction between the tire and the road its value depend mainly on the type of the tire ,the type of the road and the car weight .

For the pneumatic tires(الاطارات التي تعمل بالهواء المضغوط),the rolling resistance is affected by the followings factors

- 1.The number of tire plays
- 2.The tire diameter.
- 3.The type of tire rubber
- 4.The tire air pressure.

The rolling resistance (R_r) may be calculated from the following equation

$$R_r = W * r$$

where

r is the coefficient of rolling resistance (<1)

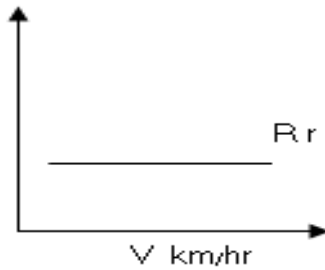


Fig (4) The relationship between the rolling resistance and the car speed

Example(4)

Calculate the rolling resistance for a car of 2400kg mass .The coefficient of rolling resistance was (0.4)

Example(5)

Determine the value of the coefficient of rolling resistance for a car of (8)ton mass having a rolling resistance of (15)N/ton

The Total resistance (R_t)

Its the summation of all pervious resistances (R_a , R_g , R_r)

$$R_t = R_a + R_g + R_r$$

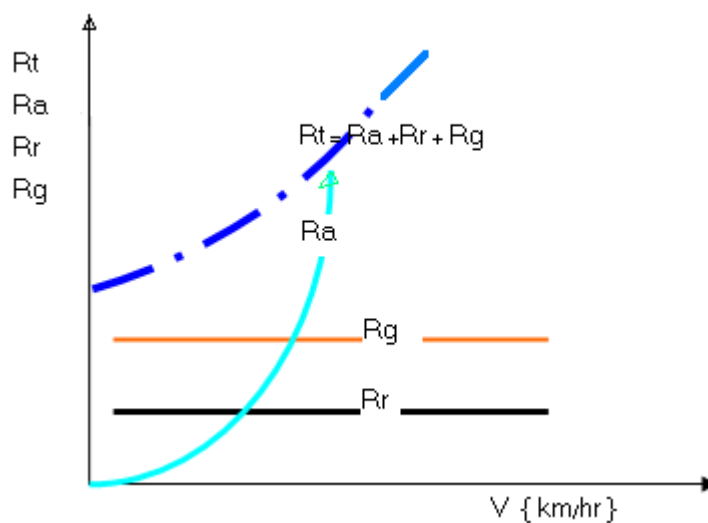


Fig (5) The relationship between the air, gradient , rolling and total resistance with the car speed

Example(5)

A car of (6) ton mass was moving up a road of 1/30 gradient by a speed of 50km/hr .The car frontal area was 2.7m^2 .The coefficient of air resistance was 0.03 and the coefficient of rolling resistance was 0.04 .

CACULATE the followings

- 1.The air resistance (R_a)
 - 2.The gradient resistance (R_g)
 - 3.The rolling resistance (R_r)
 - 4.The total resistance (R_t)
-

Example(6)

Calculate the total resistance for a car moving on a level road by a speed of 120km/hr .the car frontal area was 3m^2 and the coefficient of air resistance was 0.05 The rolling resistance was 30% of that of air resistance

Example(7)

A car of (4)ton mass was moving on an inclined road of 18%gradient at a speed of 75km/hr.The coefficient of rolling resistance was (0.025).Neglect(اهمل) the air resistance and calculate the total resistance.

2)TRACTION EFFORT (Te)

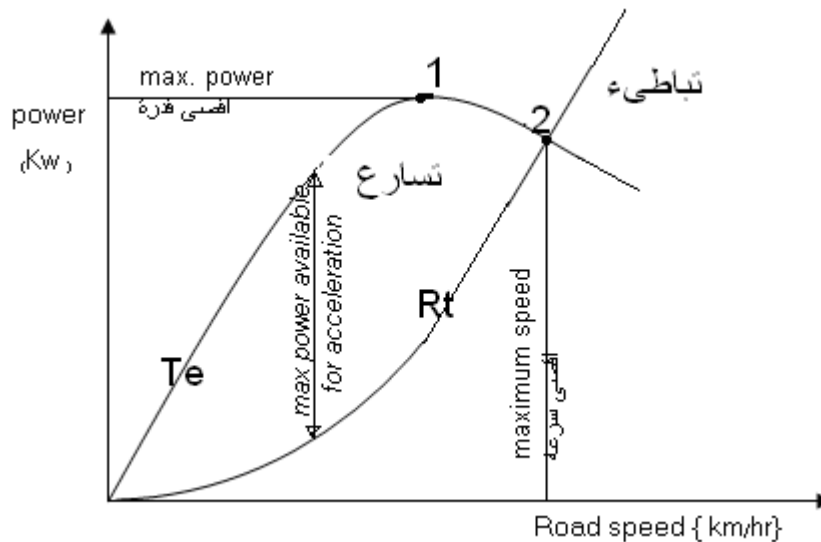
Its the forces available at the wheels provided from the engine through the transmission system to overcome the total resistances(R_t). To ensure the vehicle movement (TE) must be more than (R_t)

If

$T_e = R_t$ then the car will move at a constant speed

$T_e > R_t$ then the car will be accelerated and a surplus force will be produced

$T_e < R_t$ then the car will be decelerated and then stop.



Fig(6):The relationship between the car speed with the traction effort and the total resistance

point (1) represent The max. available engine power

point (2) represent The max. car speed ,when the power available at wheel was equale to the tractive resistance power required i.e $T_e = R_t$

In ganeral

T_e are calculated from the following equation

$$T_e = F + R_t$$

$$F = M.a$$

Where

F- is the surplus force (N)

a – the car acceleration (m/s²)

ALSO

$$T_e = \frac{T_w}{r}$$

$$T_w = T.G.\eta$$

Then

$$T_e = \frac{T.G.\eta}{r}$$

BU

$$Bp = \frac{2\pi NT}{60}$$

or

$$Bp = 0.1NT$$

$$T = \frac{10Bp}{N}$$

$$T_w = \frac{10Bp.G.\eta}{N}$$

Then

$$T_e = \frac{10Bp.G.N\eta}{N.r}$$

ALSO

$$P_w = Bp.\eta$$

Then

$$T_e . V = Bp . \eta$$

And

$$V = \frac{0.1N.r}{G}$$

The equations of linear motion is represented by the following

$$V_2 = V_1 + a t$$

$$S = V_1 t + 0.5 a t^2$$

$$V^2_2 = V^2_1 + 2 a S$$

Where Bp – the brake power, P_w - Wheel power , N – rpm
 G - the overall gear ratio, η - the transmission efficiency
 V_2 -the final speed(m/s)
 V_1 -the initial speed (m/s) , t - time (s)
 S – distance(m)

Example(8)

A car was moving by a constant speed of 70km/hr using the 3rd gear of a gear box having (4) gear ratio .its engine develops 85Kw at a speed of 4000rpm the drive axle gear ratio was (3) and the engine develops its max torque and power at 1500&3500rpm Take the transmission efficiency as 80% and the wheel diameter 50cm.

- Calculate
- 1) The total resistance
 - 2) The wheel power.
-

Example(9)A car of 1.8 ton mass was moving upward a road of (1/20) gradient by a speed of 89km/hr and an acceleration of (0.45)m/s² .The coefficient of rolling and air resistance was 0.03 &0.02 respectively. The car engine develops 60kw by a transmission efficiency of 80%.CALCULATE the car frontal area.

Example(10) A car of (2) ton mass with a frontal area of 3.1m² and a wheel diameter of 66cm was moving upward a road of 3% gradient The coefficient of air resistance was 0.03 and the air resistance may be taken as 150N/ton .the overall gear ratio was 4.1:1 by a transmission efficiency of 75% . If the torque was 166N.m CACULATE the followings

- 1) The air resistance
 - 2) The gradient resistance
 - 3) The rolling resistance
 - 4) The total resistance
 - 5) The traction effort.
 - 6) The car acceleration
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Example(11) Calculate the car acceleration for a car of 1200kg mass moving by a speed of 60km/hr on a road of 25⁰ gradient The coefficient of air and rolling resistance was 0.02&o.o4 respectively .Te traction effort was calculated to be twice (ضعف) than that of the total resistance .

Example(12) A car of 3.5 ton mass was moving upward a road of 4:200 gradient by a speed of 65km/hr .the rolling resistance was 75N/ton the air resistance was

120N Calculate the traction effort NOW if the car engine was turned off what will be the stopping distance

Example(13)

A car of 2450 kg mass was moving upward a road of 1% gradient The engine develops 87Kw at a speed of 3780rpm by a transmission efficiency of 90% and a overall gear ratio of 505:1 The wheel radius is 40cm The car frontal area was 2.2m^2 The rolling resistance was 268N and the coefficient of air resistance was 0.04 .Calculate the car acceleration.

Example(14) Sketch a diagram showing the relationship between the air , gradient ,rolling and total resistance with the vehicle speed

Example(15) Write down the factors which effected the rolling resistance.

Example(16) Complete the following with suitable phrases

- 1.The air resistance is depend mainly on the
 2. The gradient resistance is depend mainly on the
 - 3.The rolling resistance is depend mainly on the
 4. $R_a = \dots\dots\dots$
 5. $R_r = \dots\dots\dots$
 6. $R_g = \dots\dots\dots$
 7. $T_E = \dots\dots\dots$
 - 8.The traction effort is the driving force available at
 9. If $T_E > R_t$ then the car will.....
 10. If $T_E < R_t$ then the car will.....
 11. If $T_E = R_t$ then the car will.....
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