ASSIGNMENT - 2

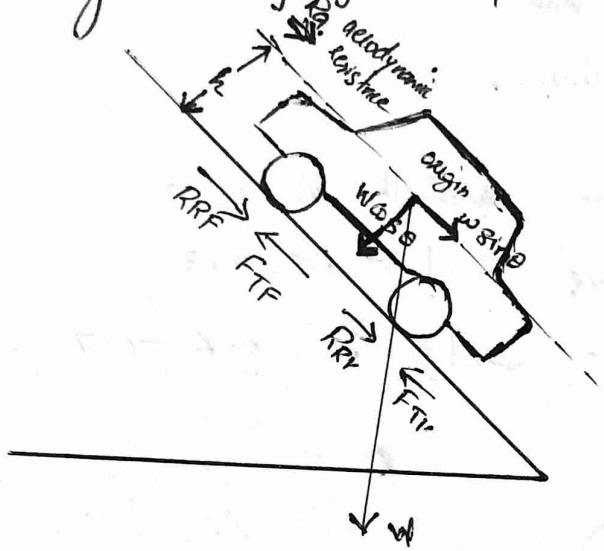
EV POWERTRAIN ARCHITECTURE AND ENERGY STORAGE SYSTEM

UNIT-2 : ELECTRIC VEHICLE POWERTRAIN SELECTION

SUBMITTED BY

DHANESH. K.A

Qn 1. Derive the Equation of motion and maximum tractive effort for a car inclined at angle θ; Also give the expression of maximum gradeability for a 4 wheel drive.



$R_a \Rightarrow$ Aerodynamic resistance.

$R_R \Rightarrow$ Rolling resistance $(R_R = R_{RF} + R_{Rr})$

$F_T \Rightarrow$ Reaction force $(F_T = F_{TF} + F_{Tr})$

$h \Rightarrow$ Height from road to origin

$$R_a = \frac{1}{2} \rho C_d \times A \times V^2$$

$\rho = 1.225 kg/m^3$ at $25^\circ C$

V = Relative velocity

A = Projected area of the vehicle

C_d = Drag coefficient

- $W \sin\theta$ is responsible for the moving back tendency.

R_g = Gravitational resistance / Gradiant resistance

$R_g = W \sin\theta$; θ = gradiant angle

~~$R_g = W\theta$~~ $\quad \theta = 0 \quad \therefore R_g = 0$

$\theta = 90 \quad \therefore R_g = W(max)$

$R_R \rightarrow$ Rolling resistance.

$R_R = R_{RF} + R_{RR}$ ie Rolling resistance front + Rolling resistance back.

$R_R = \mu_R W \cos\theta$ Here μ_R = Rolling coefficient

N_R depends on some parameters such as :-

* pressure of tyre
* surface of tyre
* tyre construction
* Tyre temperature

Rolling coefficient for asphalt is 0.02
for mud is 0.3
for sand is 0.6 - 0.7

$F_T = F_{TF} + F_{TR}$ ——— (1)

$F_T - (R_a + R_g + R_R) = ma$

$F_T = ma + R_a + R_g + R_R$

$$\text{Gradeability} = 100 \times \left(\frac{T_F}{\text{Gravity} \times GVW} - R_R \text{ coeff} \right)$$

(N_R) coeff

↓

It is the vehicles ability to climb slopes

T_F - Here T_F is the traction force

R_R coeff → μ_R → rolling resistance coefficient

GVW → Gross vehicle weight.

W → weight of the car.

R_R & R_F → total normal reaction at front & rear wheels.

F = max. forward acceleration

F_F = max tractive force

$\Sigma V = 0$ ——— (2)

$\Sigma H = 0$ ——— (3)

I_F → Inertia force = $mf - W \sin\theta$

$mf - mg \sin\theta$

$\frac{w}{g} f - W \sin\theta$ ——— (1)

Using (2)

$$W\cos\theta = R_F + R_R \quad \text{---(4)}$$

Using (3)

$$F_F = \frac{W}{g}\cdot f + W\sin\theta \quad \text{---(5)}$$

$$R_f = \frac{W}{g}\cdot f + W\sin\theta \quad \text{---(6)}$$

$$R_f = \frac{W}{g}f + \frac{W}{\mu}\sin\theta \quad \text{---(7)}$$

$$R_f = \frac{W}{\mu}\left(\frac{f}{g} + \sin\theta\right)$$

Taking moment about x.

$$R_f \times b + \left(\frac{W}{g}f + W\sin\theta\right)h = W\cos\theta \times l$$

$$\left(\frac{W}{g}\frac{\theta}{W} + \frac{W}{\mu}\sin\theta\right)b + \left(\frac{W}{g}f + W\sin\theta\right)h = W\cos\theta \times l$$

$$\frac{b}{\mu}\left(\frac{f}{g} + \sin\theta\right) + \left(\frac{f}{g} + \sin\theta\right)h = \cos\theta \times l$$

$$\left(\frac{f}{g} + \sin\theta\right)\left(\frac{b}{\mu} + h\right) = \cos\theta \times l$$

$$\left(\frac{f}{g} + \sin\theta\right) = \frac{\cos\theta \times l}{\left(\frac{b}{\mu} + h\right)} \quad \text{---(8)}$$

$$\frac{f}{g} = \left(\frac{\cos\theta \times l}{\left(\frac{b}{\mu} + h\right)}\right) - \sin\theta$$

$$F = g\left[\left(\frac{\cos\theta \times l}{\left(\frac{b}{\mu} + h\right)}\right) - \sin\theta\right] \quad \text{---(9)}$$

$$R_F = \frac{W}{\mu} \times \frac{\cos\theta \times l}{\left(\frac{b}{\mu} + h\right)} \quad \text{---(10)}$$

$$= \frac{W\cos\theta \cdot l}{b + \mu h}$$

$$R_R = W\cos\theta - R_F$$

$$= W\cos\theta - \frac{W}{\mu}\,\frac{\cos\theta \times l}{\left(\frac{b}{\mu} + h\right)}$$

$$= W\cos\theta\left[1 - \frac{l}{(b + \mu h)}\right]$$

$$w\cos\theta\left[\frac{b+\mu h - l}{b+\mu h}\right]$$

$$F_f = N_{RF} = N \times \left(\frac{w\cos\theta\, l}{b+\mu h}\right)$$

Four wheel drive

$$F = R_F + F_f = \mu R_R + \mu R_F$$

$$\Sigma V = 0$$

$$w = R_F + R_R$$

$$(w/g)F = \mu R_R + \mu R_F$$

$$= \mu(R_R + R_F) = \mu w$$

$$(8/g) = \mu$$

$$\Sigma V = 0$$

$$w = R_R + R_F$$

$$\Sigma M = 0$$

$$(w/g)F = \mu R_R + \mu R_F$$

Assuming slip to occur at front wheels

just $R_F < R_R$ ~~then~~

$$\therefore 2\mu R_F = (w/g)F$$

$$\Sigma M_R = 0$$

$$R_F b + (w/g)F h = wl$$

Q2. Consider a car with the following specifications that is parked on a level road. Find the load on the front and rear axles $m = 1765\ kg$, $l = 2.84\ m$, $a_1 = 1.22\ m$, $a_2 = 1.62\ m$

$M = 1765\ kg$

$l = 2.84\ m$

$a_L = 1.22\ m$

$a_2 = 1.62\ m$

Load on front axles $= F_{AF} = mg\left(\frac{a_2}{l}\right)$

Load on rear axles $= F_{AR} = mg\left(\frac{a_1}{l}\right)$

$F_{AR} = mg\left(\frac{a_1}{l}\right)$

$= 1765 \times 9.8\left(\frac{1.22}{2.84}\right)$

$= 17297 \times 0.429$

$= 7430.40N$

$\therefore$ Load on rear axles $= 7430.40\ N$ //

$F_{AF} = mg\left(\frac{a_2}{l}\right)$

$= 1765 \times 9.8\left(\frac{1.62}{2.84}\right)$

$= 17297 \times 0.570$

$= 9866.59N$

$\therefore$ Load on front axles $= 9866.59\ N$ //

Q3. What are the different parts of tires? Differentiate between types of tires on the basis of their construction.

Tire Construction

* Bead ⇒ Bead is made up of spring wire.
The bead hold the tire to the rim or the outer edge of the wheel. They are made up of copper, brass, or bronze-plated high tensile steel wires wounded into a rubber band.
Bead prevent the tire from sliding out of place when the wheel rolls.

* Bead filler ⇒ It is a rubber compound inside the tires beads. It provide stability to the lower side wall & bead area

* Inner liner ⇒ It is made up of soft rubber compound
1# body play
2# body play

The inner liner is a rubber compound bounded to the inside of the cord body that retains air under pressure. It has no cord or reinforcement & it function like an inner tube. The modern car tires no longer have inner tube inside them. A tire's beads, bead filler & inner liner work together to hold air within the tire walls.

* Side wall ⇒ The area of the tire from the bead to the tread. The side of the tire is called side wall. It forms a protective covering for the cord body. Information about tire is printed on the side wall.
* Steel belt ⇒ It provide strength to the tire. The presence of steel belt help to prevent pa bending.
* Sholder insert ⇒ Provide proper strength to the sholder
* Sholder ⇒ It is the weakest & thinnest portion of the tire.
* Tread ⇒ It is the position of the tire that comes in contact with the road surface. The tread compound & its design have to balance wear, traction, handling, fuel economy, resistance, etc.

On the basis of construction tires are of two types

1. Cross ply tyre construction.
2. Radial ply tyre construction.

→ Bias tires.

① Cross ply tire construction.

This is also known as bias ply tyre construction. This tyre has better resistance against wear. They have good bonding to the road. A Cross ply tire consist of carcas

layers made from nylon. Cord wheels are placed diagonally along each other in the tread & the sidewall at an angle of 50°. Multiple rubber plies stacked over each other which form a thick layer, which makes them less flexible as a result. They are more sensitive to over heating.

Advantage.

* This tyres provide high stability.
* They also provide good resistance against sidewall damage
* These tyres are economical as their production is cheaper.

Disadvantages

* Due to rolling resistance this tires heat up quickly.
* Cross ply tires being rigid, prove to be less comfortable.
* Due to high resistance of tyre fuel consumption is high.

② Radial ply tire construction

This construction of a carcass ply which is formed by textile cords running on bead to the other. Each ply embedded at an angle of 90° to the rolling direction. At the top of tire crown several plies are reinforced with metal wire on the top of the carcass ply.

Advantage

* These tyres have a lower rolling resistance due which leads
* to the less fuel consumption.
* They have a longer tread life as less heat generated
* Provide better breaking efficiency.

Disadvantages

* Their soft sidewalls are vulnerable
* Due to harder thread they make noise.
* These tyres have a steel belt due to which it does not have well grip on minor humps in the road.