Report for ABS



→ ABS are meant to control the wheel slip in order to maintain the friction coefficient close to the optimal value

→ wheel slip :- Relative motion between a wheel and the surface of the road, during vehicle movement.

consider vehicle moving in a straight direction under braking conditions.

so for horizontal direction

$$F_f = F_i \quad (1)$$

$F_f$ → frictional force

$F_i$ → inertial force

$$F_f = \mu \cdot m_v \cdot g \quad (2)$$

$m_v$ - total vehicle mass

$g$ - gravitational acceleration

$F_i = m_v \cdot a_v$ ($a_v$ - vehicle acceleration)

where $a_v = \frac{dv_v}{dt}$ (3)

∴ vehicle acceleration (from (1), (2), (3))

$$\frac{dv_v}{dt} = \frac{1}{m_v}(\mu \cdot m_v \cdot g)$$

ABS system has to control onthe wheel slip around an optimal target.

For slip,

$$S = 1 - \frac{\omega_w}{\omega_v}$$

$\omega_v \rightarrow$ equivivalent angular speed of the vehicle

$$\omega_v = \frac{V_v}{r_w}$$

$V_v$ (m/s) $\rightarrow$ vehicle speed

→ friction coefficient depends on several factors like – wheel slip, vehicle speed, the type of road surface

- For our purpose we are going to take into account only the variation on wheel slip.

Friction coefficient

Stability zone
- friction coeff increases with the wheel slip increases

Unstable zone
- friction coeff decreases with the wheel slip increase

Friction coeff can be expressed as empirical function, where slip is functional argument

$$\mu(s) = A \cdot (B \cdot (1 - e^{-C \cdot s}) - D \cdot s)$$

S[-] – wheel slip

A, B, C, D[-] – empirical coefficients.

Depending upon the value of coeff A, B, C, D empirical formula can be used to represent the friction coefficient for diff road types.

| | Type | | | |
|---|---|---|---|---|
| | dry | wet | Snow | ice |
| A | 0.9 | 0.7 | 0.3 | 0.1 |
| B | 1.07 | 1.07 | 1.07 | 1.07 |
| C | 0.2773 | 0.5 | 0.1773 | 0.38 |
| D | 0.0026 | 0.003 | 0.006 | 0.007 |

→ wheel model :-
wheel speed ωw ~~is initialized~~ integrator is initialized. The linear wheel speed Vw is obtained by multiplying the angular speed with wheel radius. distance covered obtained by integrating linear speed

ilp :- braking torque Tb
friction force Ff

olp :- angular wheel speed ωw
linear wheel speed Vw
wheel distance dw

→ controller :-
bang-bang type controller, reacting on wheel slip feedback. max value of friction coeff is obtained around slip of 20% (0.2). Thus target is 0.2. Slip error is the diff between actual slip & target slip.
Hydraulic system modeled as first order transfer function, amplification factor K & time const is T. olp is braking torque

$T_b$ accumulated over time by integrator.
- i/p → wheel slip S [-]
  o/p → vehicle speed $V_v$ [m/s]

→ Simulation :-
- Simulation run for 20 sec and results are stored in data inspector.

- When ABS disabled braking torque ramps up to maximum value & causes slip.
  With ABS braking torque modulated to maintain optimal slip ratio.
- When ABS deactivated wheel slip climbs to 1 as torque increases. When ABS is activated slip is controlled by controlling braking torque.
- ∴ When ABS is deactivated wheel lock before coming to complete halt. With ABS active wheel is prevented from locking thus reducing slip.